British Horological Institute

Drawing Clock and Watch Escapements

Distance Learning Course

Version 1.4

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Founded in 1858, the British Horological Institute is the professional body for clock and watch makers and repairers in the UK. It provides information, education, professional standards and support to its members around the world.

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Contents

Drawing escapements

1 The Examination

1.1 Introduction

The examination unit, 'D6 : Drawing Clock / Watch Escapements' is a mandatory unit for the following qualifications:

- Diploma in the Servicing and Repair of Clocks / Watches
- Diploma in the Repair, Restoration and Conservation of Clocks / Watches

The examination for the unit comprises two parts:

1 There is a three hour invigilated drawing examination; a pictorial drawing showing an escapement or part of an escapement is provided. You are required to draw the required elevations using the appropriate geometrical construction for the escapement. There are separate 'clock' and 'watch' examination papers.

During the examination, you may refer to the details of the geometric constructions given in this booklet

The drawing may be produced manually (A2 paper) or using CAD. If CAD is used, hard copy is required (A2 / A3 paper) and a CD with the file saved at the end of each hour and the end of the examination.

2 You are also required to complete and submit a separate drawing for assessment. The details for this drawing are determined by the Examinations Board and circulated to candidates after the closing date for examination entries. The requirements for this drawing may be generic to both 'clocks' and 'watches' or there may be separate 'clock' and 'watch' drawings.

This drawing is to be produced manually (A2 paper) or using CAD. If CAD is used, hard copy is required (A4 / A3 paper). You are permitted to refer to the geometric constructions given in this booklet.

1.2 Rationale

An understanding of the principles of orthographic projection used in technical drawing enables the clock or watchmaker to make freehand sketches as well as formal drawings. The ability to use the geometric constructions to design a recoil escapement and a dead beat escapement is essential for the candidate to successfully enter the units:

- The Recoil Escapement, Design and Construction
- The Dead Beat Escapement, Design and Construction

The club toothed lever escapement is the commonest escapement for watches and platform escapements. The ability to draw the components using standard constructions enhances the understanding of the working principles of the escapement and assists the watchmaker in the diagnosis and correction of faults.

1.3 Assessment

Each of the drawings will be assessed by considering the following criteria:

1. Use of drawing conventions in accordance with current standards, BS 8888
2. Accuracy of the geometric construction used for the escapement drawing.
3. Accuracy of the detail for the components.

An overall mark will be awarded to include the drawing completed in the examination and the drawing submitted separately:

- Examination drawing – a maximum of 75% of the overall mark
- Submitted drawing – a maximum of 25% of the overall mark

1.4 General information

For candidates who do not have previous experience of technical drawing and a knowledge of the various conventions which are used for horological drawings it will be helpful to refer to the Technical Drawing lessons in the Preliminary Grade Distance Learning Course. There is also information available in the Helping Hand articles, nos. 11 – 13 (Booklet 2) and on the Institute website – www.bhi.co.uk, follow the link Education and scroll down to ‘Menu 1’, ‘Technical Drawing Checklists’.

Dotted lines have been used to denote construction lines throughout this booklet. Candidates drawing manually are to use thin pencil lines when drawing the construction lines. Candidates using CAD may use dotted lines with a fine ‘dash scale’.

Drawing the Recoil Escapement

2 Recoil escapement, drawing the wheel and pallets

2.1 Introduction

The recoil escapement is the most common escapement for pendulum clocks; it is sometimes necessary to draw the design for pallets and the escape wheel either to make a replacement escapement or replacement pallets. It is straightforward to construct because each pallet has only one working face. The geometrical construction enables two points on the acting face of each pallet to be determined:

1. the point on the pallet face which arrests the escape wheel teeth – the lock point.
2. the discharging corner of the pallet

The shape of the pallet face joining these points can vary from escapement to escapement; for the earliest recoil escapements it was a flat surface, but in a modern escapement it is generally convex. This tends to reduce the recoil during the supplementary arc.

Before commencing to draw the escapement, it is necessary to know:

1. the diameter of the escape wheel
2. the number of teeth
3. the number of teeth to be embraced by the pallets. This will always be a number of whole tooth spaces plus half a space, e.g. 6½, 7½, 8½. The number of teeth embraced by the pallets can sometimes be expressed in different ways which may give rise to confusion.
4. the escaping angle, or the arc through which the pallets must turn for a tooth to escape. This is generally about 4^{o}.
5. the allowance for drop, expressed as an angle drawn from the centre of the escape wheel.
6. drop includes the thickness of the tooth tip, which in this case is $½^{o}$.

The escapement data should be inserted in a table on the finished drawing.

Example escapement design data

Recoil Escapement Design Data	
Tip diameter of escape wheel	32.7 mm
Root diameter of escape wheel	26.5 mm
Number of teeth in escape wheel	36
Number of tooth spaces embraced by pallets	7½
Impulse angle of pallets (escaping angle)	4°
Allowance for drop (including ½° tooth tip thickness)	1°

2.2 The geometrical construction

The stages to construct the design for the escape wheel and pallets will be described. The rationale for the various steps is described to enable the student to use the construction to design any recoil escapement. Use A2 drawing paper and a scale 6 : 1; for CAD, a scale to fit the paper being used.

A series of instructions are provided to construct the recoil escapement; refer to Figure 1.

1. Draw the line of centres, the tip circle and the root circle of the escape wheel; letter the centre of the wheel **O**.

2. *In this instance the escape wheel has 36 teeth; therefore each tooth and space occupies an angle, measured from the wheel centre, of 360° ÷ 36 = 10°. The pallets are required to embrace 7½ tooth spaces and thus the angle embraced by the pallets is 7½ x 10° = 75°. The action of the escapement is to be symmetrical about the line of centres and therefore half of this angle will be marked out at each side of the centre line joining the axes of the escape wheel and pallets.*

   Draw the construction lines **OA**, **OB** at an angle of 37.5° on each side of the line of centres of the escape wheel and pallets. Letter the points where these lines cut the tip circle, **A** and **B**.

3. *In this example, the axis of the pallets will lie at the point of intersection of the tangents to the tip circle at points **A** and **B**.*

   Draw tangents at **A** and **B** to intersect at **P**, the axis of the pallets. Letter the axis of the pallets **P**; the distance between centres is thus **OP**.

4. *The action of the escape wheel takes place as the escape wheel turns through half a tooth space. In this example, therefore, the escape wheel actually turns 5°; drop is 1° (including tooth tip thickness). Impulse will therefore be delivered as the wheel turns through 5° - 1° = 4°. Half of this angle, 2°, must occur before each of the lines, **OA** and **OB** and half afterwards.*

   Draw the lines **OC** and **OD** from the escape wheel centre at 2° on either side of **OA**, and the lines **OE** and **OF** similarly on either side of **OB**. Letter the points **C**, **D**, **E**, **F**.

5. *The escape wheel is to turn clockwise. Assuming that a tooth has just dropped on to the entrance pallet its leading edge will lie at **C**, the 'drop point' on the entrance pallet.*
   *The discharging corner of the exit pallet will lie at **F**. Since drop of 1° has occurred, the leading edge of the tooth which has just escaped will be 1° after the point **F** and the trailing edge ½° after the point **F**.*

   Draw the wheel teeth.

6. *The pallets move through 4° during impulse; the discharging corner **G**, for the entry pallet, will thus lie on an arc drawn using the centre **P** through the point **D**.*

   Draw a line through the point **P** at an angle of 4° to **PA**, measured anti-clockwise, and then draw an arc with centre **P**, radius **PD** to intersect this line at **G**.

7. *Similarly for the exit pallet, the drop point will lie on an arc drawn using centre* ***P*** *through the point* ***E****.*

   Draw a line through the point **P** at an angle of 4° to **PB**, measured anti-clockwise, and then draw an arc with centre **P**, radius **PE** to intersect this line at **H**.

8. Join the discharging corner with the drop point for each pallet with, in this instance, an arc radius 12mm to give the impulse faces.

9. The remaining portion of the outline of the pallets can now be drawn. As the pallet faces have been drawn with the wheel tooth on the drop point for the entry pallet, the centre for drawing the curved lines which form the body of the pallets is drawn from point **R** not the centre of the wheel **O**. The impulse angle is 4^{o}, the centre, **R**, will therefore be on a line drawn through **P**, 2^{o} anticlockwise of the centre line **PO**. An arc should be drawn using centre **P** and radius **PO** to intersect this line at **R**. The decoration beyond the exit pallet gives a more balanced appearance to the pallets.

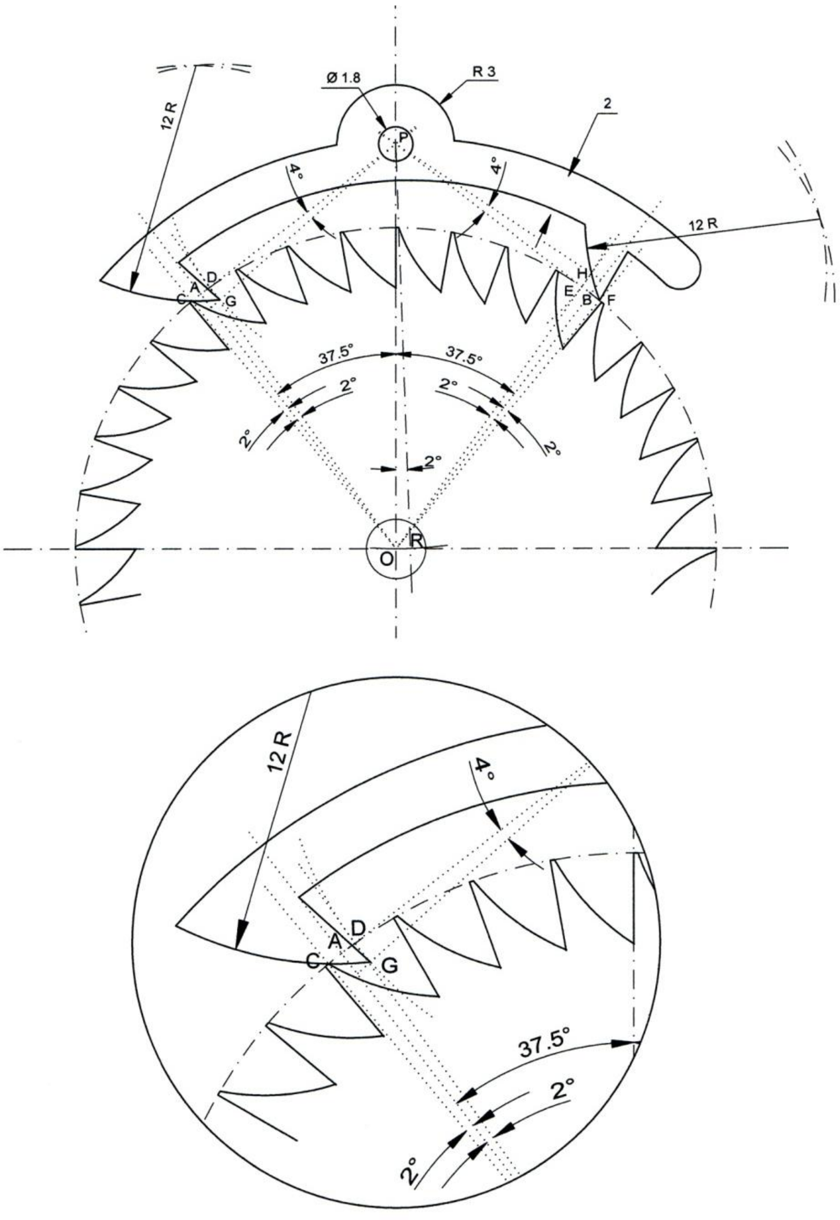

Figure 1 - drawing the recoil escapement

Drawing the dead beat escapement

3 Dead beat escapement, drawing the wheel and pallets

3.1 Introduction

There are a number of types of dead beat escapement; the following construction is for the Graham dead beat escapement which is used in pendulum clocks such as regulator clocks when a very high order of accuracy is required. It differs from the recoil escapement in that each pallet has two separate acting faces, the locking or resting face and the impulse face. There are finer working clearances for the dead beat escapement than the recoil escapement.

In the front elevation of the Graham dead beat, the locking or resting face of each pallet (sometimes called the dead face) is represented by a circular arc drawn from the axis of the pallet arbor; the impulse face is shown by a straight line. The locking faces are in fact parts of a cylinder concentric with the pallet arbor, and the impulse faces are plane surfaces. The junction of the locking face and the impulse face is known as the locking corner, and the point at which the tooth leaves the impulse face is known as the discharging corner. The point on the locking face on to which the tooth drops is called the drop point – Figure 2.

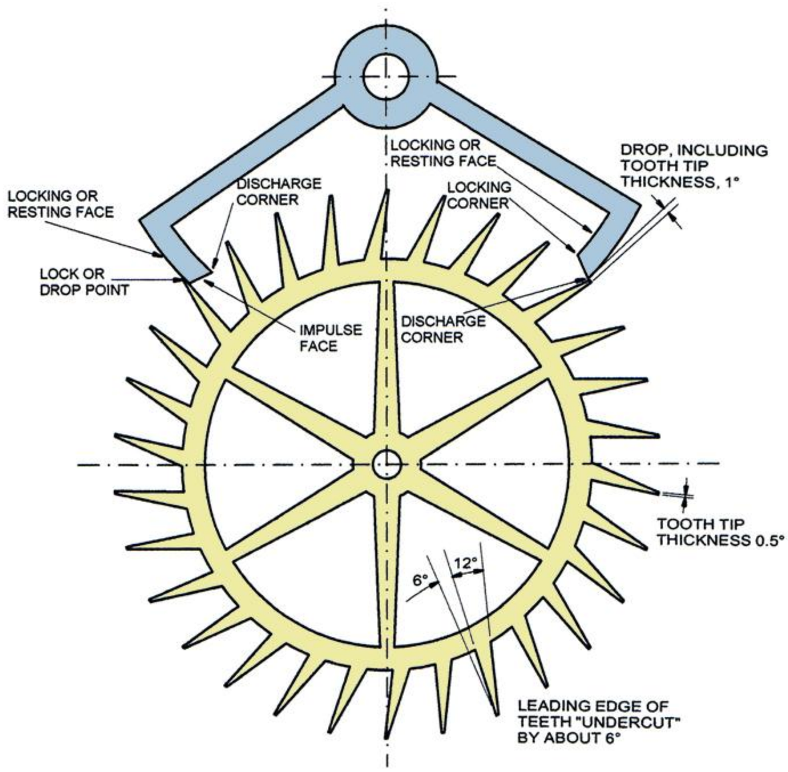

Figure 2 - Graham dead beat escapement

Before commencing to draw the escapement, it is necessary to know:

1. the diameter of the escape wheel
2. root diameter of escape wheel
3. the number of teeth - a Graham dead beat escapement is often used for a regulator clock indicating seconds on the dial; if this is the case, there will be thirty teeth.
4. the number of teeth to be embraced by the pallets. As with the recoil escapement, this will always be a number of whole tooth spaces plus half a space, e.g. 7½, 8½. Some Graham dead beat escapements can embrace 10½ or even 14½ tooth spaces. The number of teeth embraced by the pallets is sometimes expressed in different ways which may give rise to confusion, e.g. 7½ teeth.
5. the escaping angle, or the arc through which the pallets must turn for a tooth to escape. This is generally about 3^{o}, comprising lock or rest plus impulse.
6. the allowance for drop, expressed as an angle drawn from the centre of the escape wheel.
7. drop includes the thickness of the tooth point, which in this case is $½^{o}$.

The escapement design data should be inserted in a table on the finished drawing.

Example escapement design data

Dead Beat Escapement Design Data	
Tip diameter of escape wheel	48 mm
Root diameter of escape wheel	36 mm
Number of teeth in escape wheel	30
Undercut of leading edge of wheel tooth	6^{o}
Included angle of wheel tooth	12^{o}
Number of tooth spaces embraced by pallets	7½
Impulse angle of pallets (escaping angle)	3°
Allowance for drop (including ½° tooth tip thickness)	1°
Lock	1^{o}
Impulse	2^{o}

When drawing the escapement, the first stage is to determine the position of the wheel teeth, the locking corner and the discharging corner of each pallet. When these points have been constructed, the remaining details of the escapement should be drawn.

3.2 The geometrical construction

The stages to construct the design for the escape wheel and pallets will be described. The rationale for the various steps is described to enable the student to use the construction to design any recoil escapement. Use A2 drawing paper and a scale of 6 : 1; for CAD, a smaller scale will be required.

Figure 3 and Figure 4 show the overall construction for the wheel and the construction of the entry pallet; Figure 5 and Figure 6 complete the exit pallet.

1. Draw the line of centres, the tip circle and the root circle of the escape wheel; letter the centre of the wheel **O**.

2. *In this instance the escape wheel has 30 teeth; therefore each tooth and space occupies an angle, measured from the wheel centre, of 360° ÷ 30 = 12°. The pallets are required to embrace 7½ tooth spaces and thus the angle embraced by the pallets is 7½ x 12° = 90°. The action of the escapement is to be symmetrical about the line of centres and therefore half of this angle will be marked out at each side of the centre line joining the axes of the escape wheel and pallets.*

   Draw the construction lines **OA**, **OB** at an angle of 45° on each side of the line of centres of the escape wheel and pallets. Letter the points where these lines cut the tip circle, **A** and **B**.

3. *In this example, the axis of the pallets will lie at the point of intersection of the tangents to the tip circle at points **A** and **B**.*

   Draw tangents at **A** and **B** to intersect at **P**, the axis of the pallets. Letter the axis of the pallets **P**; the distance between centres is thus **OP**.

4. *The action of the escape wheel takes place as the escape wheel turns through half a tooth space. In this example, therefore, the escape wheel actually turns 6°; drop is 1° (including tooth tip thickness). Impulse will therefore be delivered as the wheel turns through 6° - 1° = 5°. Half of this angle, 2½°, must occur before each of the lines, **OA** and **OB** and half afterwards.*

   Draw the lines **OC** and **OD** from the escape wheel centre at 2½° on either side of **OA**, and the lines **OE** and **OF** similarly on either side of **OB**. Letter the points **C**, **D**, **E**, **F**.

5. *The escape wheel is to turn clockwise. Assuming that a tooth has just dropped on to the entrance pallet its leading edge will lie at **C**, the 'drop point' on the entrance pallet.*

   Draw the wheel teeth using the escapement design data.

6. *The curved resting face for the dead beat escapement must be centred at the pallet axis P and pass through the drop point **C**.*

   Draw an arc centre **P**, radius **PC**.

7. *The angle of lock is 1^o; the locking corner, **G**, must therefore lie along a line drawn at an angle of 1^o anticlockwise to the line **PC** at the point where the line intersects the curved resting face.*

   Draw a line through the point **P** at an angle of 1^o measured anticlockwise to the line **PC**. Letter the point **G** where this line intersects the line representing the curved resting face.

8. *The pallets move through 2° during impulse; the discharging corner **H**, must therefore lie on a line drawn 2^o anticlockwise from the line **PG**. To actually define the discharging corner, we must recognise that it will lie on an arc concentric to the resting face drawn through point D. The point where these lines intersect is the discharging corner.*

   Draw a line through the point **P** at an angle of 2° to **PG**, measured anti-clockwise; and then draw an arc with centre **P**, radius **PD** to intersect this line at **H**.
9. The line **GH** represents the impulse face, the curved resting face and the curved back to the entry pallet are now complete – Figure 3.

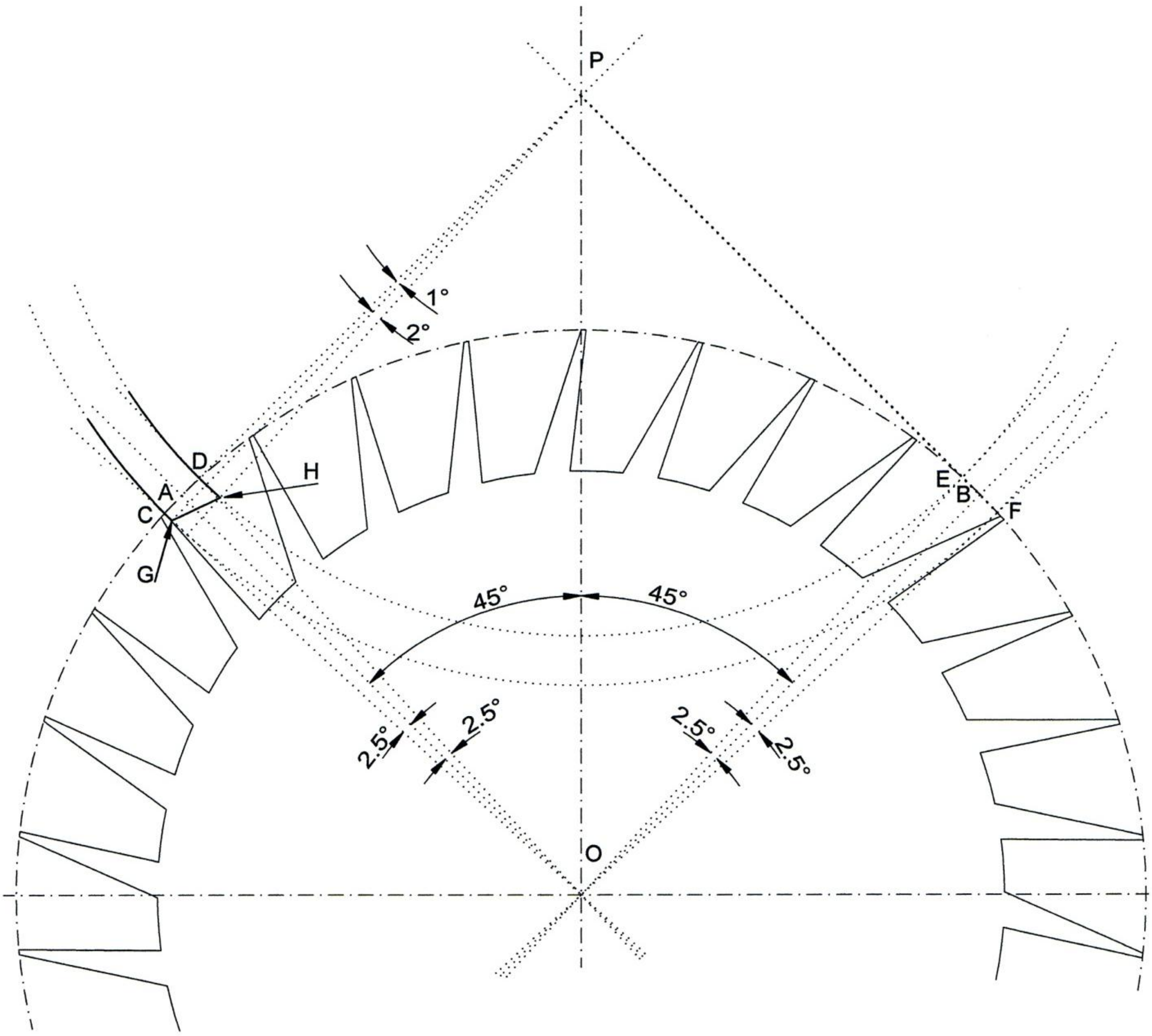

Figure 3 - drawing the entry pallet

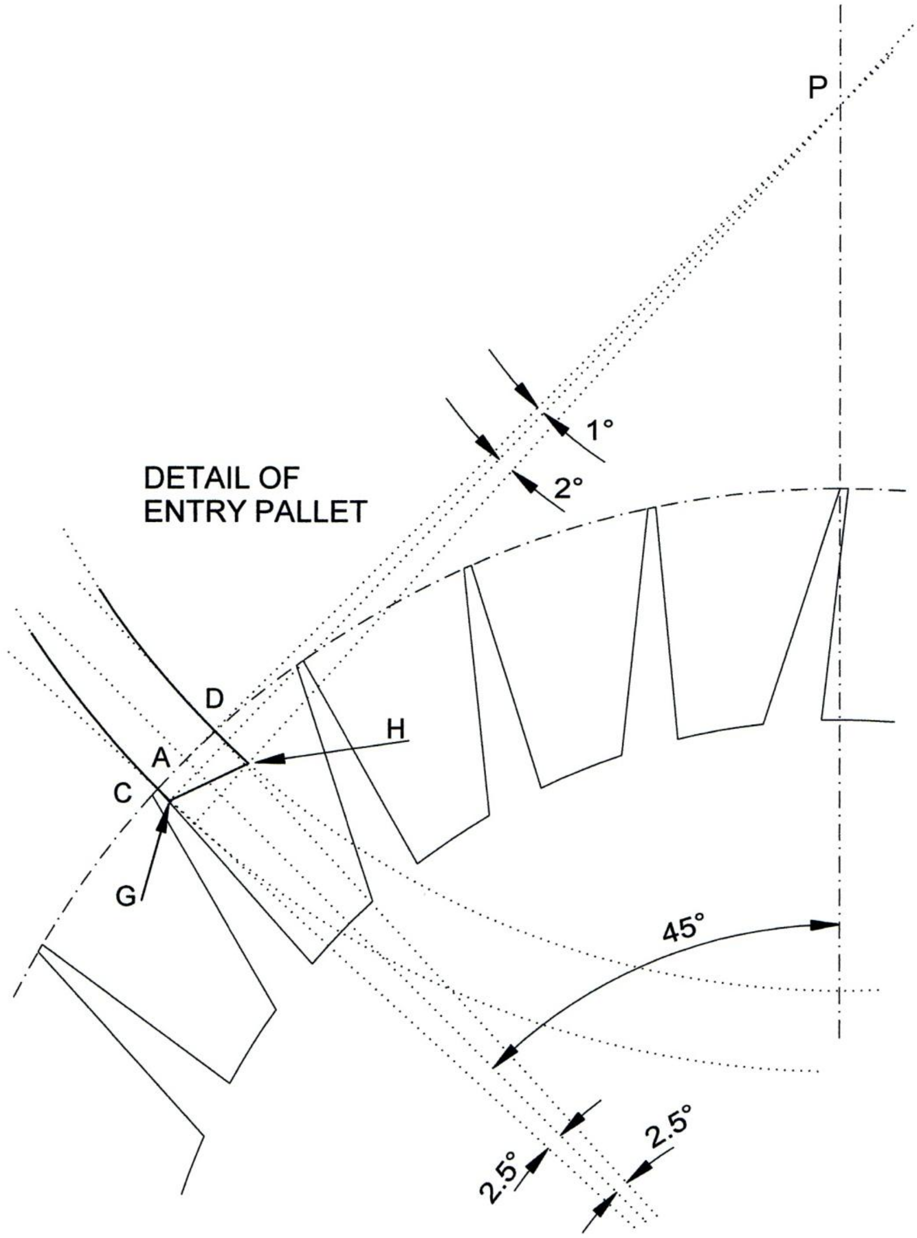

Figure 4 - detail showing construction of entry pallet

10. Now that the entry pallet has been completed, we can give our attention to finishing the exit pallet – Figure 5 and Figure 6.
    *The point **F** is the discharging corner for the exit pallet. The leading edge of the tip of the adjacent escape wheel tooth is 1⁰ away from **F** and the trailing edge of the tooth is ½⁰ away from **F**. Impulse takes place as the pallets move through 2⁰; the locking corner, **I**, will therefore lie on a line 2⁰ anticlockwise from the line **PF** drawn through the pallet axis, **P**. If it is recognised that the locking corner must lie on the curved resting face for the exit pallet, the actual position will be the point where the line **PI** intersects the curved line representing the resting face.*

    Draw a line through the point **P** at an angle of 2° to **PF**, measured anti-clockwise. The point where this line intersects the line representing the curved resting face is the locking corner, **I**.

11. The locking point, **L**, will be at the point where a line drawn through **P**, 1⁰ anticlockwise from the line **PI**, intersects the line representing the resting face.

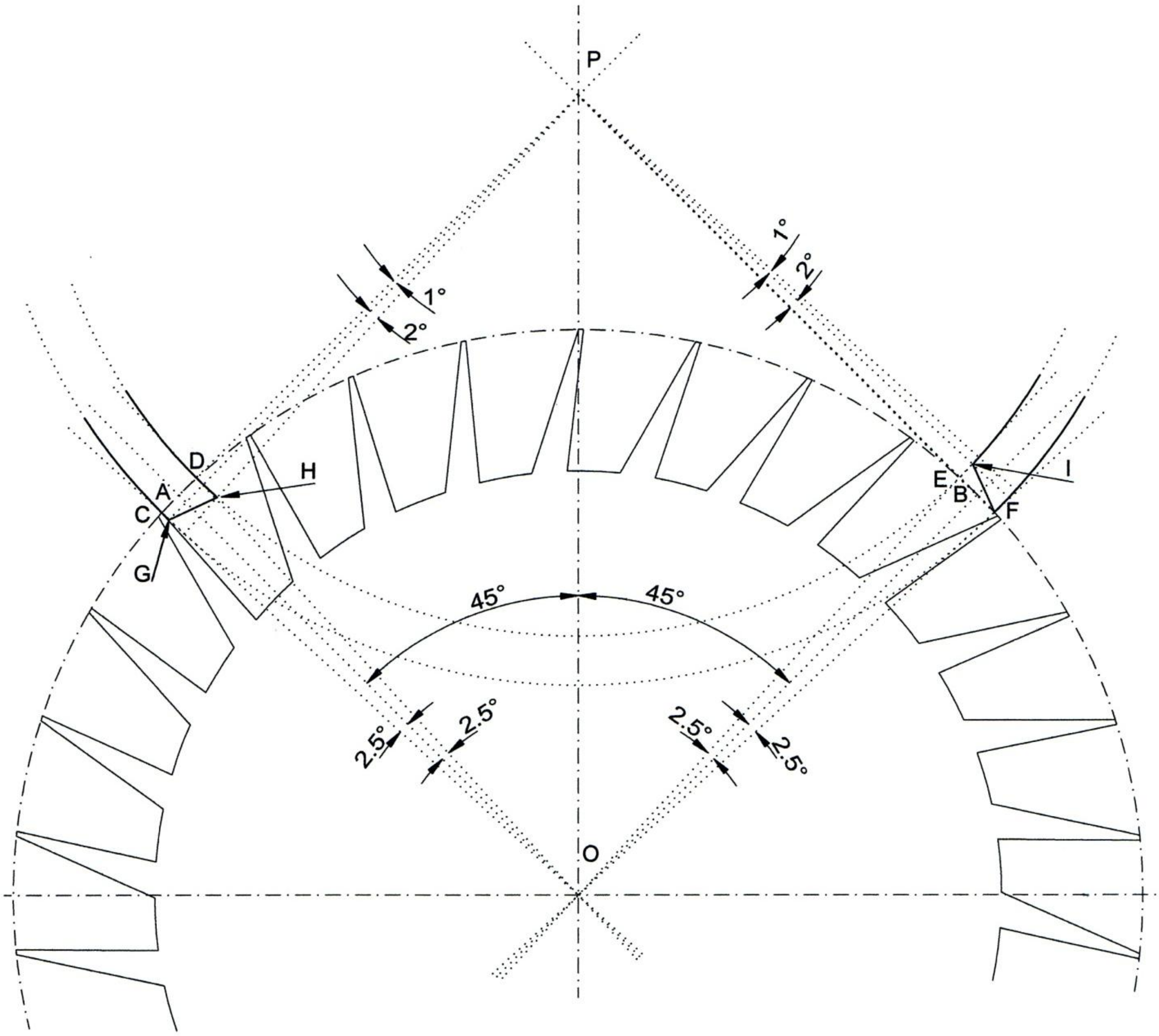

Figure 5 - drawing the exit pallet

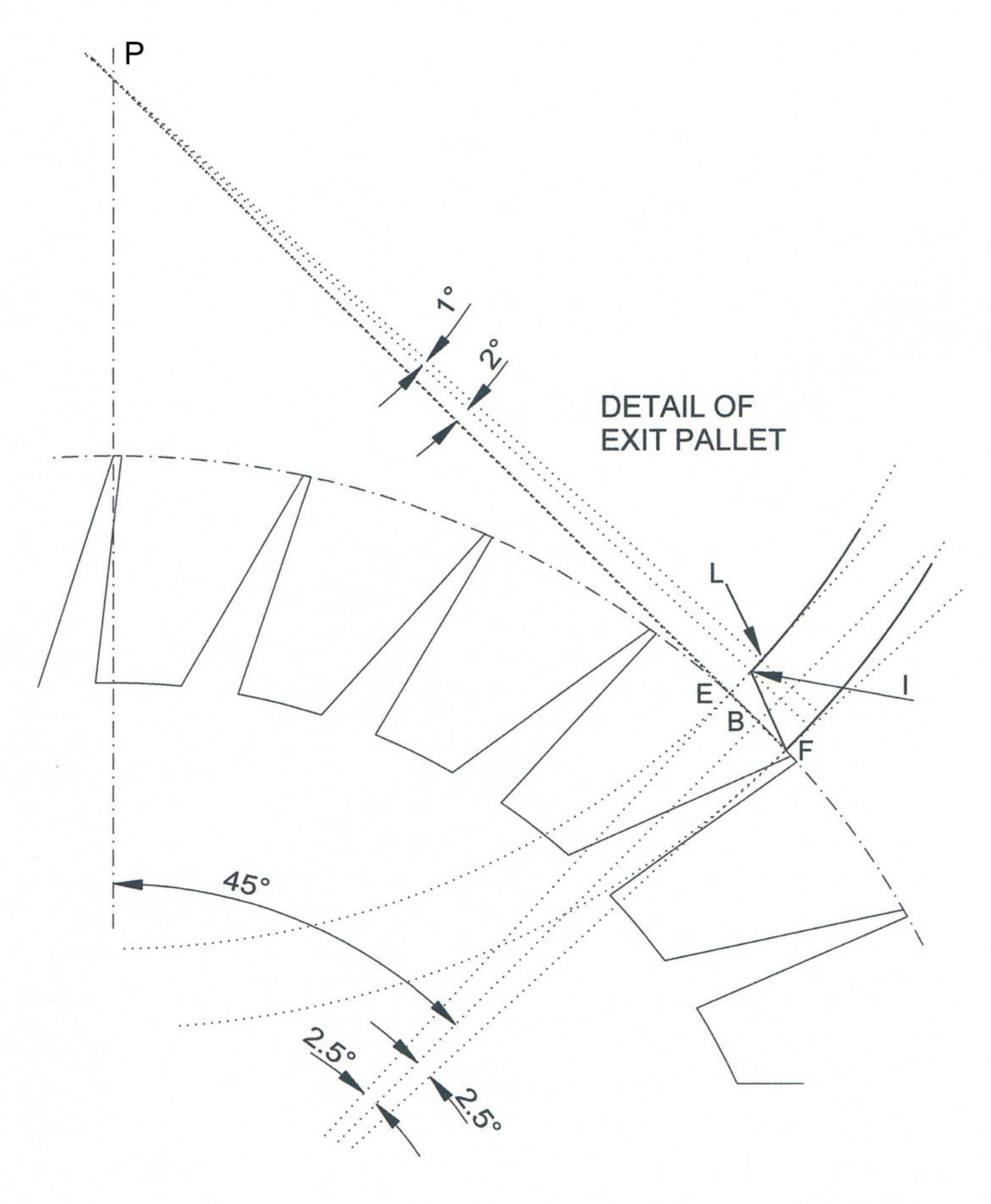

Figure 6 - detail showing construction of exit pallet

The shape of the pallets

Now that the acting faces of the escapement have been determined, the outline can be drawn and the drawing completed. The dimensions are given in Figure 7.

As with the recoil escapement, the pallets have been drawn with a tooth resting on the drop point for the entry pallet. The escaping angle of the pallets is 3^{o}, the pallet arms should therefore be drawn rotated by 1½^{o} as shown in Figure 7.

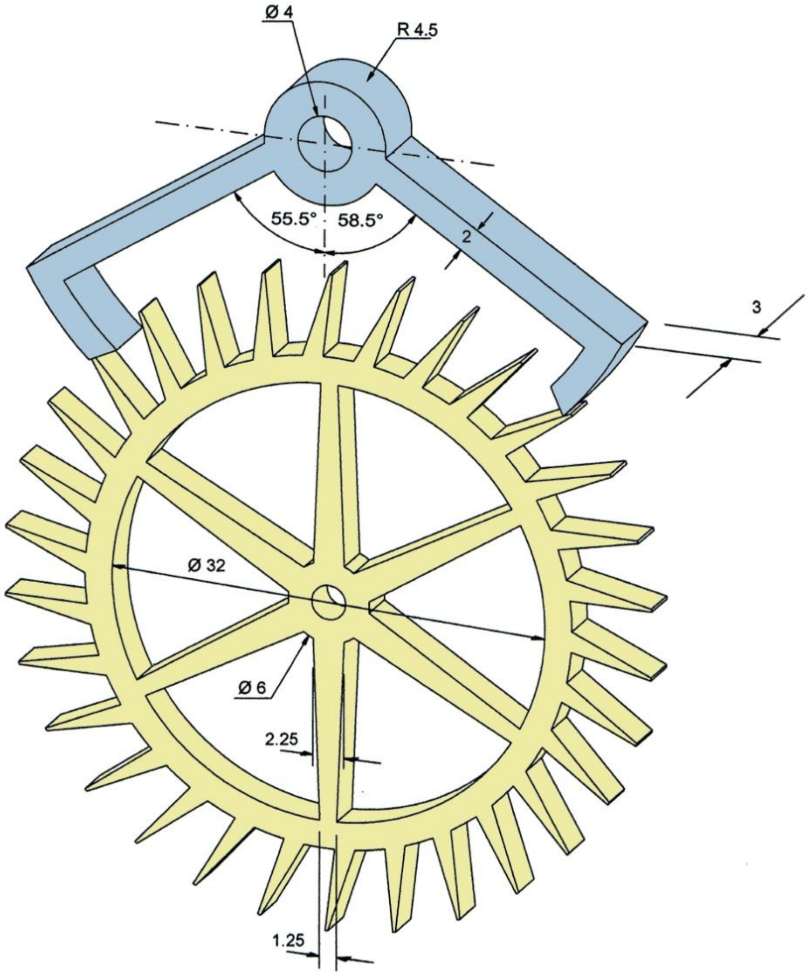

Figure 7 - dimensions for the escape wheel and pallets

Drawing the club toothed lever escapement – Part 1

4 Club toothed lever escapement, drawing the wheel and pallet action

4.1 Introduction

The club tooth lever escapement is used in the greater majority of mechanical watches produced today.

The design drawing will consist of two parts:

1. Part 1 – Wheel and pallet action - Section 4.
2. Part 2 – Roller and safety action – Section 5.

4.2 Escapement Design Data

Club Toothed Lever Escapement Design Data	
Locking radius of escape wheel	4.10 mm
Root diameter of escape wheel	6.3 mm
Number of teeth in escape wheel	15
Number of teeth embraced by pallets	2½
Drop	1°
Escaping Arc	10°
Lock	1½°
Draw angle, entrance pallet	12°
Draw angle, exit pallet	13½°
Division of combined impulse plane	Stone – 5 parts Tooth – 3 parts

4.3 The Geometrical Construction

The escapement will be drawn when a tooth has just escaped from the exit pallet. It will help to provide a reminder of the combined impulse action given by the pallet jewel and the escape wheel tooth.

Beginning with the wheel locked on the exit pallet, the movement of the balance causes the impulse pin to engage the notch in the lever and begin to rotate the lever so that the exit pallet moves away from the position of total lock. As soon as the heel of the wheel tooth passes the locking corner, impulse begins. The heel of the tooth slides across the impulse face of the pallet jewel moving the jewel outwards. The heel reaches the discharge corner of the pallet. The impulse given by the pallet jewel is complete – Figure 8, a, b, c.

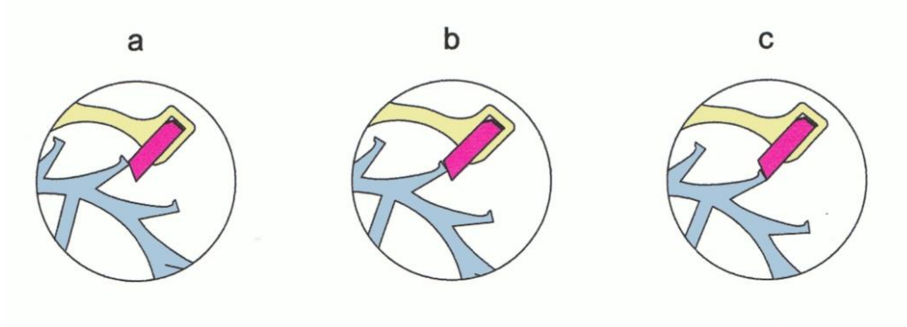

Figure 8 - Club toothed lever escapement – impulse from the pallet jewel

Impulse now continues as the sloping face on the tooth acts on the discharge corner of the pallet – Figure 9, d, e. Finally the wheel tooth escapes - Figure 9, f.

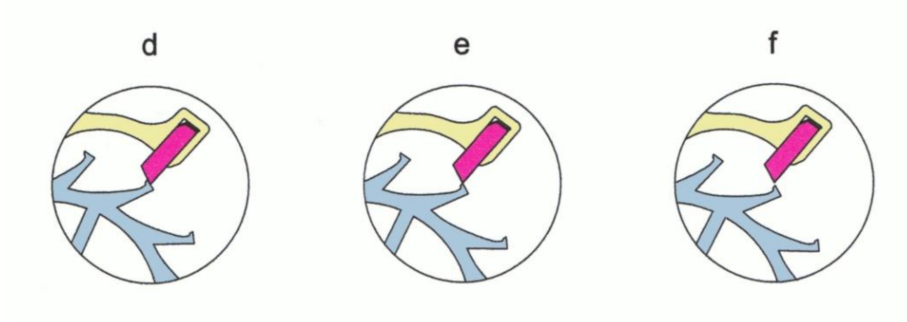

Figure 9 - Club toothed lever escapement - impulse from the wheel tooth

While the escape wheel tooth is turning forward and providing impulse, it is achieving useful work. When, however, the trailing edge of the tip of the tooth reaches the discharge corner, the wheel will move forward freely, drop occurs. During drop, no useful work is achieved.

The action of the escapement takes place in half the pitch of a wheel tooth (12^{o}); the rotation of the wheel through this angle is made up of motion which provides impulse and drop.

1. The construction commences by drawing the vertical and horizontal centre lines for the wheel intersecting at **O**, the centre of the escape wheel. The centre of the pallet staff will lie on the vertical centre line.

2. *The tooth of the club toothed lever escapement has a short impulse plane at the end of each tooth. There are two diameters which are important when drawing the escape wheel, the tip circle at which the discharge corners of the teeth revolve and the locking circle at which the locking corners of the teeth revolve.*

   We shall be drawing half of the escape wheel. Using centre **O**, draw the locking circle, Ø 8.2 mm.

3. *In this instance the escape wheel has 15 teeth; therefore each tooth and space occupies an angle, measured from the wheel centre, of 360° ÷ 15 = 24°. The pallets embrace 2½ teeth and thus the angle embraced by the pallets is 2½ x 24° = 60°. The action of the escapement is to be symmetrical about the line of centres and therefore half of this angle will be marked out at each side of the centre line joining the axes of the escape wheel and pallets.*

   Draw the construction lines **OA**, **OB** at an angle of 30° on each side of the line of centres of the escape wheel and pallets. Letter the points where these lines cut the locking circle, **A** and **B** and the end of the lines extended beyond the locking radius **R** and **T** as shown in Figure 10.

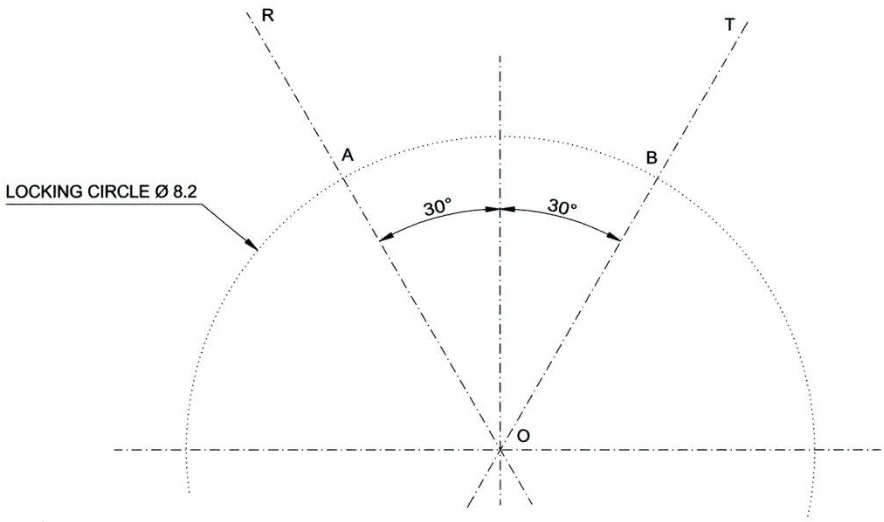

Figure 10 - the action is symmetrical about the lines of centres

4. *The axis of the pallets will normally lie at the point of intersection of the tangents to the tip circle at points **A** and **B**.*

   Draw tangents at **A** and **B** to intersect at **P**, the axis of the pallets. Letter the axis of the pallets **P**; the distance between centres is thus **OP** – Figure 11.

5. Continue to draw the wheel using the dimensions given in Figure 11.

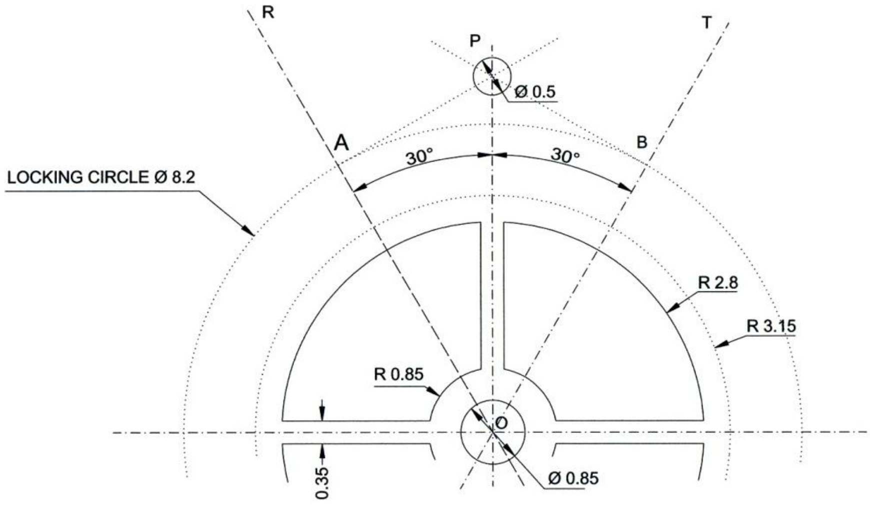

Figure 11 - drawing the wheel - stage 1

6. *For the club toothed lever escapement, during the action of an escape wheel tooth on the impulse plane of a pallet stone, the following sequence of actions takes place, (terminology - exit pallet and escape wheel tooth – Figure 12,* Figure 13*:*
   a. *After unlocking, the locking corner of the tooth pushes its way along the impulse plane of the pallet jewel, imparting impulse to the balance via the pallet lever and impulse jewel.*
   b. *When the locking corner of the tooth reaches the discharge corner of the pallet jewel, the action of the tooth and pallet jewel are reversed. The escape wheel continues to provide impulse to the balance via the pallets by the impulse plane of the tooth pushing away the discharge corner of the pallet jewel.*
   c. *This action continues until the discharge corner of the tooth reaches the discharge corner of the pallet jewel. At this point, drop occurs.*

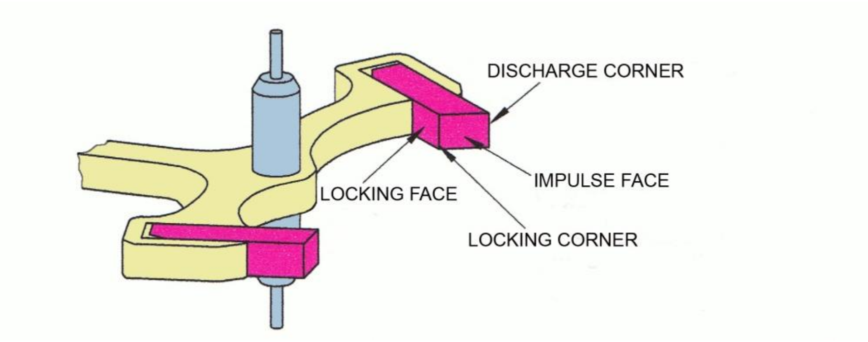

Figure 12 - the exit pallet

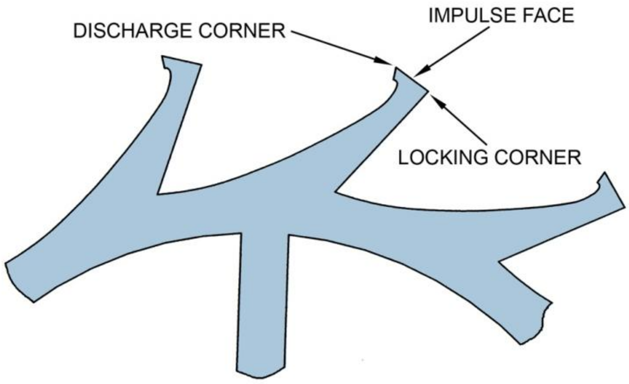

Figure 13 - an escape wheel tooth

Impulse is thus provided from the impulse plane of the pallet jewel and also from the impulse plane at the tip of the tooth – the tooth tip thickness. This is in contrast to the action of the recoil escapement and the dead beat escapement where the tooth tip thickness does not provide impulse. For the club toothed lever escapement there is no equivalent to tooth tip thickness as there is in any escapement using a pointed escape wheel.

The action of the club toothed lever escapement takes place in half of a tooth pitch; impulse (useful action) and drop (action which does not provide impulse). The escapement design data for this escapement gives 1^o drop; this *value would increase as the quality of the escapement decreases and greater clearances are necessary. Drop can be from 2^o to 2½^o.*

In the escapement which we are drawing, half the tooth pitch of the wheel is:

$$\frac{360^0}{15 \times 2} = 12^0$$

As drop is specified as 1^o, the impulse or useful motion will be provided as the escape wheel turns through:

$$12^0 - 1^0 = 11^0$$

*This useful motion of the escape wheel can be disposed in different ways relative to the construction lines **OA** and **OB** – Figure 14:*

a. *If the action is symmetrically divided about the lines **OA** and **OB**, the escapement is known as **'circular pallets'**.*

b. *When the action starts on **OA** and **OB,** it is known as **'equidistant locking'**.*

c. *Any variation between these extremes is known as **'mixed escapement'**.*

*We will be drawing an **'equidistant locking'** escapement.*

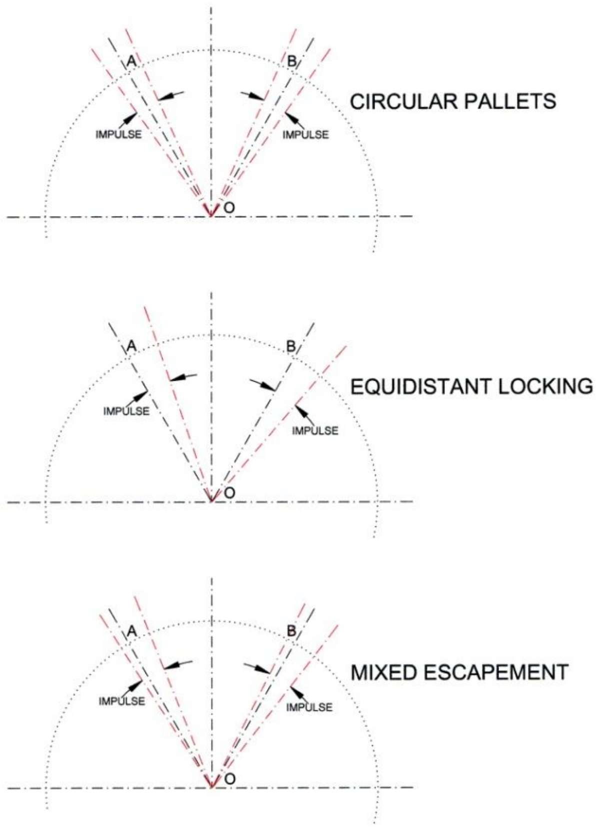

Figure 14 - the impulse can be distributed in different ways

For the equidistant escapement, draw a line from the centre of the escape wheel, **O**, 11^{o} clockwise from **OA** and a line 11^{o} clockwise from **OB**. Letter the points where these lines intersect the locking circle, **C** and **D**, respectively.

Impulse action of the escapement commences on the lines **OA** and **OB**; the points **C** and **D** are the points where the impulse action ends.

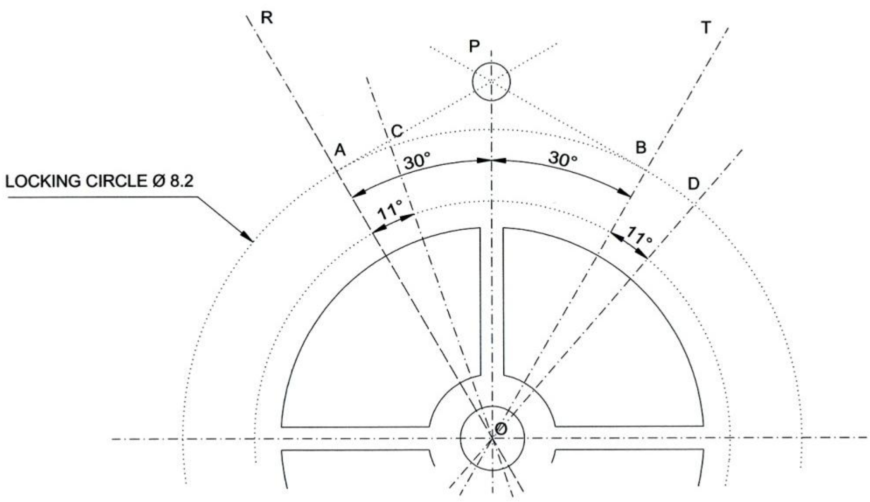

Figure 15 - Drawing the extent of the escapement action

7. *To draw a club toothed lever escapement, we must commence at the position of the wheel and pallets at the point where an outgoing tooth is about to escape from the exit pallet.*
*The locking corner of the outgoing tooth must therefore lie at the point **D** which is 11^o clockwise from **OB**, 11^o being the extent of engagement of the wheel tooth with the pallet jewel - the impulse or useful action. The position of the discharge corner has yet to be determined.*

*The locking corner of the exit pallet must have passed through the point at which action commenced, **B**. It must therefore lie on a circular arc drawn from the centre of the pallet staff, radius **PB**.*

It must lie outside the locking circle of the escape wheel by:
escaping arc (10^o) – lock (1½^o) = 8½^o.

Draw an arc using centre **P** and radius **PB**; draw a line through **P**, 8½^o anticlockwise of the line **PB**. The point of intersection of this line and the arc defines the present position of the locking corner of the exit pallet. Letter this point **F** – Figure 16.

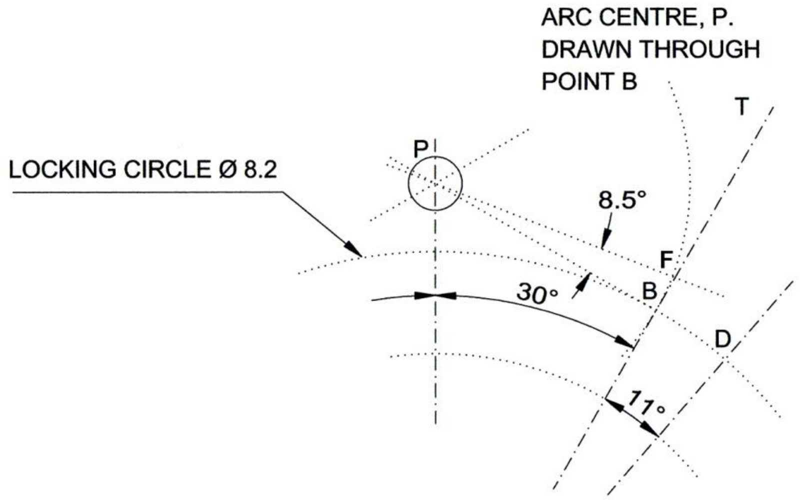

Figure 16 - the locking point of the exit pallet

8. *The line **FD** is the combined impulse plane of the exit pallet jewel and the wheel tooth at the moment of discharge; the discharge corner of the exit pallet jewel and the discharge corner of the wheel tooth are coincident. If you refer back to the sequence of actions for the wheel and pallets this is shown in Figure 9 (e). An enlarged version is given in Figure 17. A careful examination of Figure 17 will show:*
   - *The pallet jewel impulse plane and the escape wheel tooth impulse plane are in a straight line.*
   - *The pallet jewel impulse plane is longer that the escape wheel tooth impulse plane. The proportion pallet jewel impulse plane to escape wheel tooth impulse plane for this drawing is 5 : 3.*

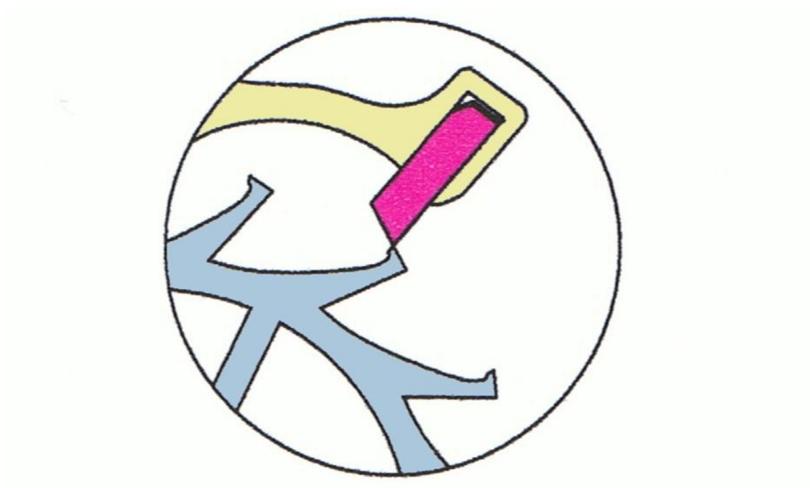

Figure 17 - the common impulse plane

Draw the line **FD** to show the combined impulse plane.

9. *The actual proportion of the pallet jewel impulse plane to escape wheel tooth impulse plane can vary but we shall use the ratio 5 : 3.*

   *The combined impulse plane, **FD**, is to be divided into eight parts to determine the length of the pallet jewel impulse plane and the wheel tooth impulse plane.*

   Divide the line **FD** into eight parts, any method may be used but the geometrical construction is shown in Figure 18.

   Five parts will form the pallet jewel impulse face and three parts the wheel tooth impulse face. Letter the point where the impulse face of the jewel ends and the impulse face of the wheel tooth starts **H**.

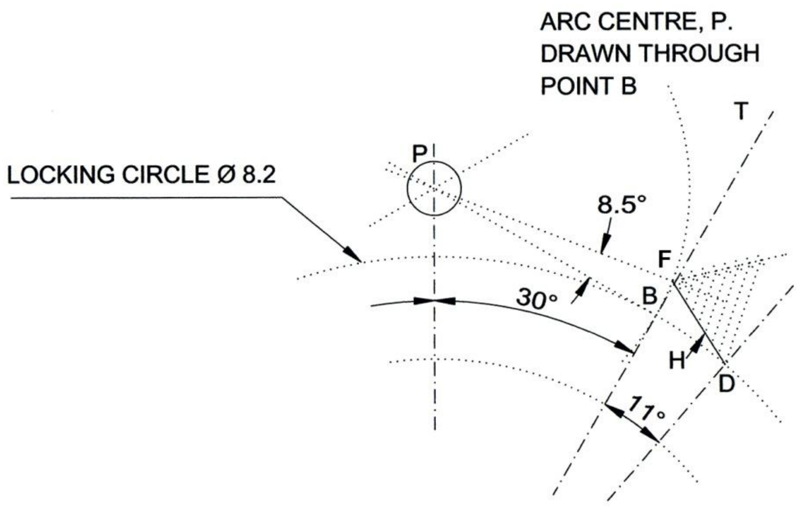

Figure 18 - determining the extent of the pallet impulse face

10. *The point H is the discharge corner of the wheel tooth and also indicates the full diameter of the escape wheel.*

    Using centre **O** draw the tip circle of the wheel through point **H**.

11. *Having determined the impulse plane of one tooth, the profile for each tooth can be drawn.*

    The dimensions to enable the profile to be drawn are given in Figure 19. Use geometrical constructions to ensure that curves and lines meet precisely.

    If you are using CAD, one tooth can be drawn and then, with 'radial copy', the remaining teeth can be created. If drawing manually, the angle between each tooth is 24°; mark out successive angles of 24° from **OH** on the tip circle to give the discharge corners for each tooth. For each point thus marked, draw an arc of radius the length of the tooth impulse face to cross the locking circle to give the locking corner of each tooth. Joining the discharge corners to the locking corners will produce the impulse faces. The profile can then be drawn for each tooth.

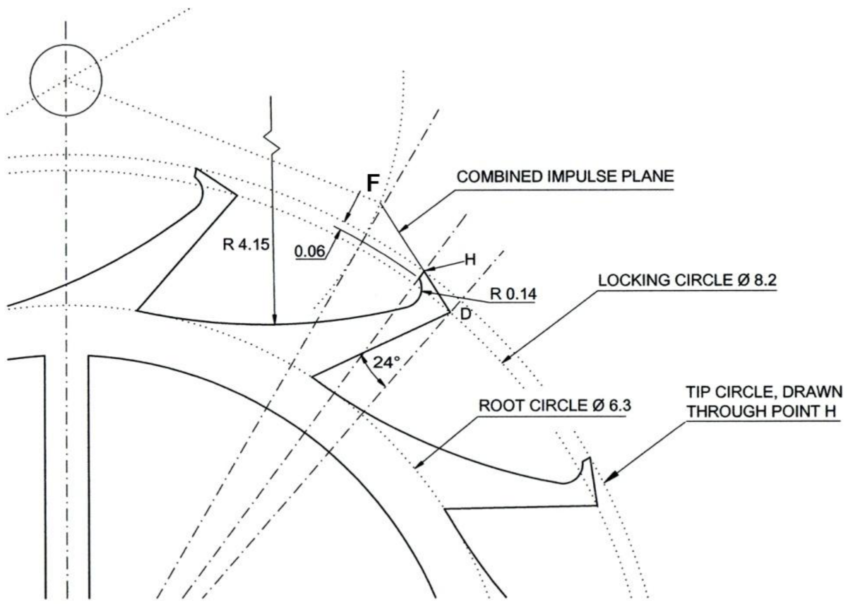

Figure 19 - drawing the tooth profile

12. *If you have drawn the escape wheel teeth accurately, you will note that the locking corner of the escape wheel tooth nearest to the entry pallet is 1° away from the line **OA**. The process of drawing the escapement commenced with the point during the action of the escapement when an escape wheel tooth had just completed impulse to the exit pallet; drop was just about to commence. The 1° clearance between the tooth nearest to the entry pallet and the line **OA** represents the drop which is about to occur.*

13. *The locking corner of the entry pallet can now be determined. It must lie inside the locking circle of the escape wheel by an amount equal to the angle of lock (specified as 1½^o in the escapement design data).*

*As the lever moves, the locking corner of the entry pallet must pass through the point of commencement of the action of the escapement, **A**. It will therefore lie on an arc drawn through **A** using centre **P**. As the drop is 1½^o, the locking point of the entry pallet must lie at a point on a line 1½^o anticlockwise of **PA**.*

Using centre **P**, draw an arc which passes through point **A**. Draw a line from **P**, 1½^o anticlockwise of line **PA**. The point at which the line intersects the arc through **A** is the locking corner of the entry pallet. Letter this point **I**.

14. *The next stage is to determine the position of the discharge corner of the entrance pallet. When the action of a tooth with the entrance pallet is about to end, the locking corner of the tooth must lie at the point defining the end of the action with the entrance pallet – point **C**. The first step is to draw the position of the escape wheel tooth impulse plane at the position when impulse is complete.*

Draw the escape wheel tooth impulse plane so that the leading corner, the locking corner, is at point **C**:

a. Using CAD, select locking face and, using the centre of rotation as the centre of the escape wheel, **O**, rotate the locking face through 12^o.
b. Drawing manually, with compasses set to the length of the impulse plane of the escape wheel tooth; draw an arc using centre **C** to intersect the escape wheel tip circle. Joining this point of intersection with point **C** will give the impulse plane of the wheel tooth at the end of its action.

Letter this point **E**. The impulse face of the escape wheel tooth, **EC**, is shown in red - Figure 20

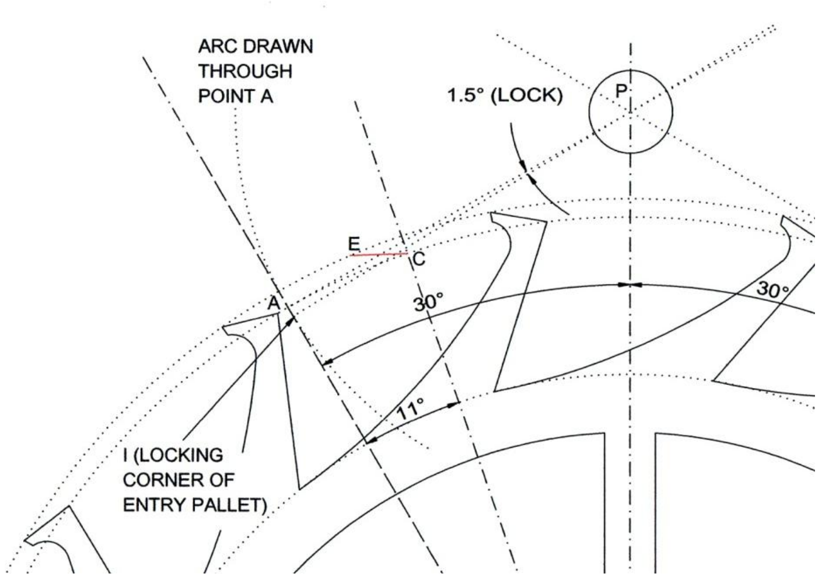

Figure 20 - drawing the entry pallet impulse face, stage 1

15. *At this point in the action of the escapement, point **E** coincides with the discharge corner of the entry pallet jewel.*

    *The discharge corner of the entry pallet jewel moves in a circular arc drawn from the centre of the pallet staff **P**. Its position will be anticlockwise of **E** by an angle equal to the escaping arc for the escapement (escapement design data: 10°).*

    Draw an arc using centre **P** and radius **PE**. Draw a line from **P**, 10° anticlockwise of **PE** (inside the wheel). The point at which this line intersects the arc will define the position of the discharge corner of the exit pallet. Letter this point **M**.

    Draw a line to join the locking corner **I** to the discharge corner **M** – This is the impulse plane of the entry pallet jewel. Coloured red in Figure 21.

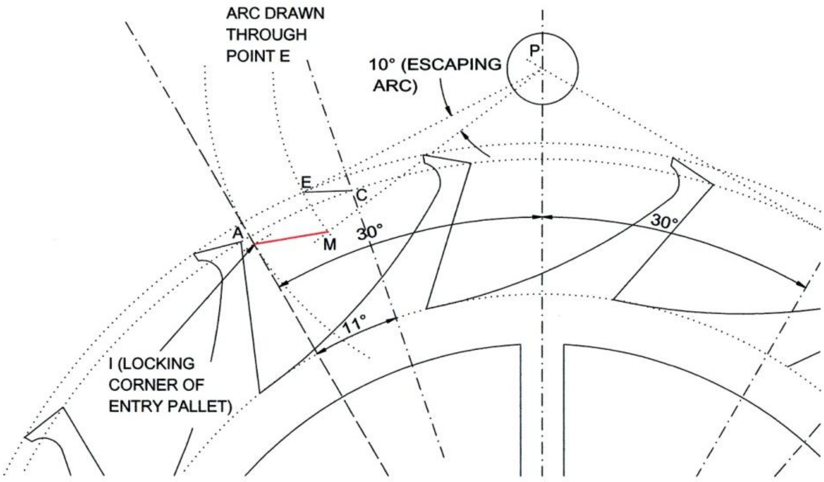

Figure 21 - drawing the entry pallet impulse face, stage 2

16. *The impulse plane for each of the pallet jewels has now been drawn; the next step is to construct the draw angles. Draw will commence to operate at the point when the escape wheel tooth drops onto the pallet jewel. The direction of zero draw is represented for each pallet by a line at right angles to a line joining the point where the escapement action commences to the pallet staff. For our drawing, it will be at right angles to **PA** and **PB**. The lines for zero draw are therefore **AR** and **BT –*** Figure 22*.*

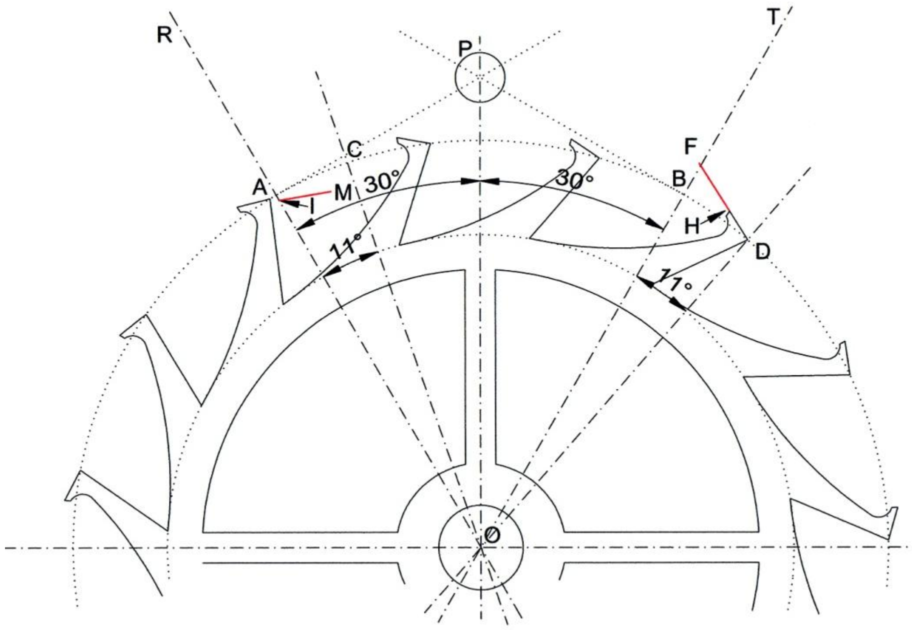

Figure 22 - zero draw is shown by **AR** and **BT**

17. *With reference to Figure 22, the direction of zero draw for the entry pallet is **AR**. The escapement design data gave 12° for the draw angle for the entry pallet.*

    Draw a line from **A**, 12° clockwise to the line **AR** to represent the angle of draw for the entry pallet. This line passes through **A** rather than the locking corner of the pallet jewel, **I**. Draw a line passing through **I**, parallel to the line representing the angle of draw for the entry pallet – Figure 23.

18. *For the exit pallet, there is an additional point to consider; the pallet frame has to rotate through the escaping arc (10°) to be aligned in the position for locking. If the present position of the exit pallet jewel is to be considered, the locking face will be:*

    *13½° (draw, exit pallet) – 10° (escaping arc) = 3½° clockwise of **BT***

    Draw a line from **B**, 3½° clockwise to the line **BT** to represent the angle of draw for the exit pallet. This line passes through **B** rather than the locking corner of the pallet jewel, **F**. Draw a line passing through **F**, parallel to the line representing the angle of draw for the exit pallet – Figure 23.

    The pallet jewels are parallel and the second face of each pallet jewel can therefore be drawn through the discharge corner, parallel to the locking face.

    The entry pallet is 1.8 mm long from the discharge corner; the exit pallet is 1.9 mm long from the discharge corner. The pallets jewels can now be drawn; the dimensions for the bevel are: 0.375 long x 0.03 wide.

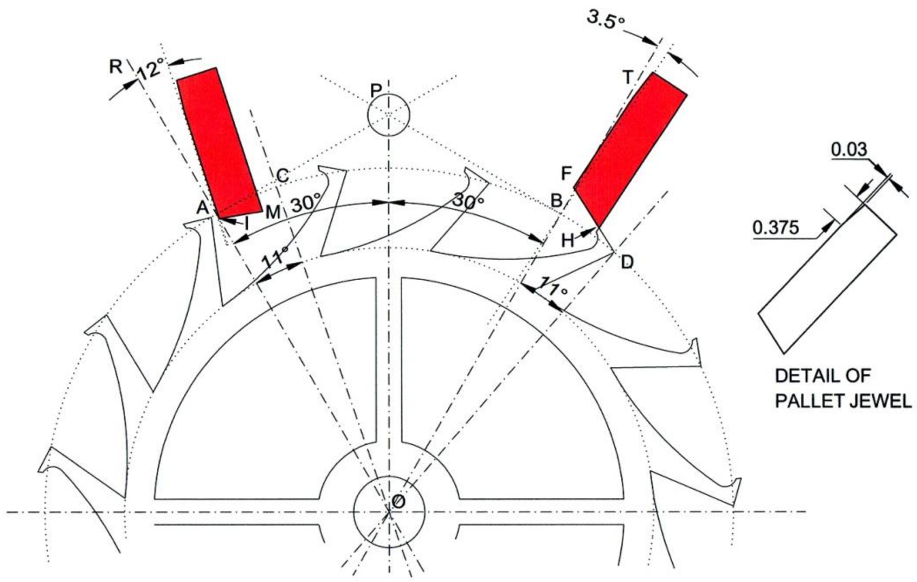

Figure 23 - drawing the entry and exit pallet jewels

19. The dimensions for the pallet frame are given in Figure 24. The pallet frame can now be drawn to complete the drawing of a club tooth escapement, wheel and pallet action.

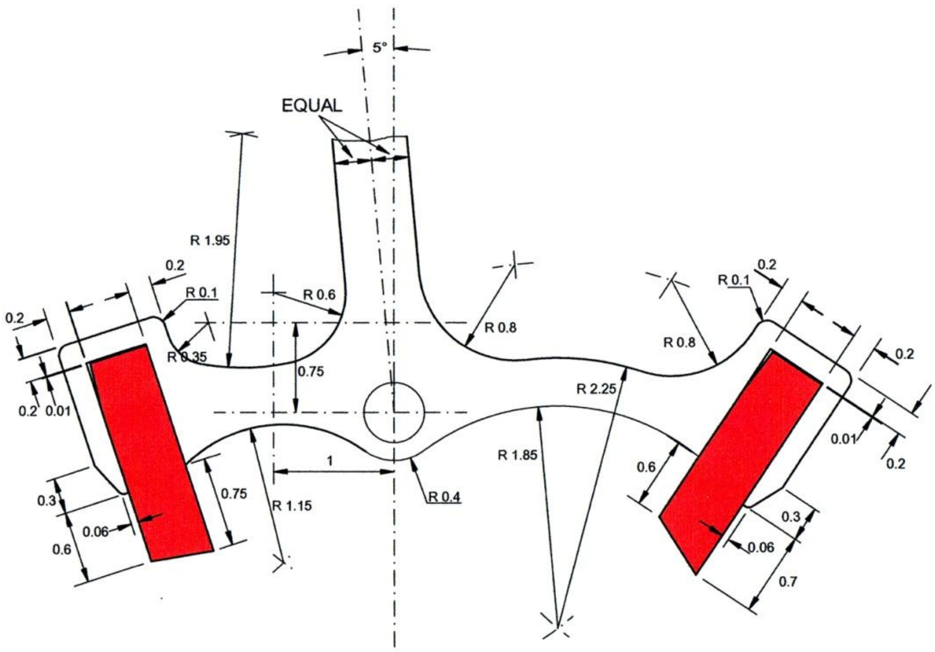

Figure 24 - pallet dimensions

Drawing the club toothed lever escapement – Part 2

5 Club toothed lever escapement, drawing the roller and safety action

1.5 Introduction

We have drawn the escape wheel and pallets for the club tooth lever escapement; the notch and roller action will now be considered. This consists of two distinct aspects:

1. The notch and impulse pin which enable energy to be transferred from the escape wheel via the pallets and lever to the balance in order to maintain the oscillation of the balance.
2. The safety action which ensures that the lever does not move across to the wrong side of the impulse pin (overbanking) because of a shock received to the watch during use.

1.6 The notch and roller action

In a watch with double roller safety action, the impulse pin is mounted on the large roller or, in a watch with a single roller, on the table roller – Figure 25. The single roller safety action is to be found on older watches. The impulse pin is normally made of synthetic ruby or synthetic sapphire. In old English lever watches it was frequently made of garnet. Many forms of impulse pins have been used, common types being the oval, triangular and D-shaped pin. Today, the D-shaped pin is generally used and normally consists of a circular pin with a flat ground on it so that the thickness, measured from the flat, is two-thirds of the diameter of the pin. The diameter of the impulse pin ranges from 0.6 mm in a very large pocket or deck watches to 0.27mm in small wrist watches.

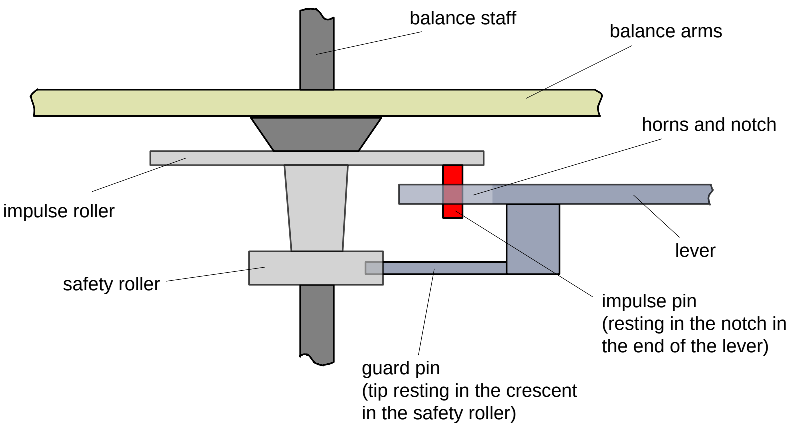

Figure 25 - The impulse roller and the safety roller

The double roller safety action consists of a small secondary roller, known as the small roller or safety roller, which acts in conjunction with the guard pin. The purpose of the safety action is to prevent premature unlocking of the escapement, which might happen if the watch received a shock when the impulse pin was clear of the notch. Should such a shock occur, the guard pin will contact the edge of the safety roller, which is highly polished, and thus prevent the lever from moving across to the opposite banking or any intermediate position.

When the impulse pin is clear of the notch, a shock can cause the lever to move until the guard pin touches the edge of the safety roller, this movement must be considerably smaller than the total angle of locking - the angle of locking at drop plus the angle representing the run to the banking. If the movement of the lever was greater than the total angle of locking, the escape wheel would unlock. This movement of the guard pin is called the guard pin clearance and is normally expressed as an angle measured from the pallet staff. The angular movement of guard pin is the same as the movement of the lever; in this instance it is 1^o**.** The length of the guard pin should ensure that, when the lever has turned 1^o, the tip of the guard pin just comes into contact with the edge of the safety roller. The clearance between the tip of the guard pin and the safety roller is called the guard pin shake – Figure 26.

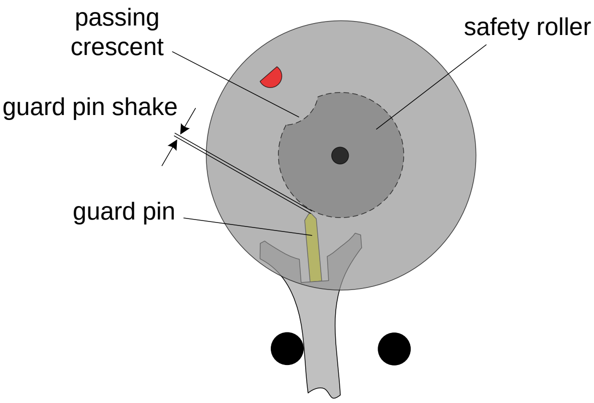

Figure 26 - guard pin shake

Part of the circumference of the safety roller must be cut away to allow the guard pin to pass from one side to the other when the impulse pin engages in the notch and brings the lever towards the centre line of the escapement. This cut-away is called the passing crescent or passing hollow.

The diameter of the safety roller varies; the smaller the diameter, the deeper will be the intersection of the guard pin with the passing crescent. There will also be less friction should the guard pin touch the safety roller. The length of the horns, however, must increase as the radius of the safety roller becomes smaller; in practice the safety roller is generally made with a radius equal to approximately 0.6 of the radius to the centre of the impulse pin.

The diameter of the large roller is not part of the geometry of the notch and roller action. It should be sufficiently large to allow the D-shaped hole for the impulse pin to be punched without distortion of the metal on the outside. In this case, the diameter of the large roller is twice that of the safety roller.

The guard pin and safety roller do not provide safety action when the guard pin enters the passing hollow. The secondary safety action to prevent the lever overbanking is achieved by the horns on either side of the notch. These horns are in the same plane as the notch and will therefore intercept the impulse pin and guide it into the notch – Figure 25.

Sometimes, with high quality watches, the face of the D-shaped impulse pin is convex; the radius is concentric with the axis of the balance staff. The corners of the D should be slightly relieved so that the flat face and curved body are joined by and arc of small radius. If the safety action comes into operation following a shock between the ending of the safety action provided by the guard pin and safety roller and the entry of the impulse pin into the notch, the friction between the guard pin and the horn will be less if a rounded and polished surface is presented to the surface of the horn instead of a sharp corner.

5.1 Drawing the notch and impulse pin

We shall explain the geometrical construction used to draw the notch and impulse pin using the following escapement design data:

- Centre distance from pallet staff to balance staff – 6.5 mm
- Escaping arc – 10^{o}
- Lock at drop – 1½^{o}
- Run to the banking – ½^{o}
- Engaging arc of the balance – 34^{o}
- Guard pin clearance – 1^{o}
- Dimensions of impulse pin – diameter 0.6 mm, thickness 0.4 mm

It will be assumed that the balance with the rollers is rotating in an anti clockwise direction and the impulse pin has entered the notch and is about to move the lever from its banking pin. The scale 50 : 1 will be used for the drawing. The stages to be followed for the drawing are numbered and will refer to drawings showing the construction at various stages; where necessary, an explanation will clarify features of the construction.

To draw the notch and impulse pin, the following need to be determined

- Centre of the impulse pin
- Flanks of the notch of the lever
- Junction of notch with horns
- Path traced by the impulse pin
- Bottom of the notch
- Radius of the safety roller

1. Draw the centre line between the pallet staff and the balance staff with its rollers – Figure 27.

2. Letter the centre of the pallet staff '**P**' and the centre of the balance staff '**S**' at a distance of 6.5 mm apart – Figure 27.

For normal operation of the lever escapement, the notch and roller action will commence with the lever resting against one or other of the banking pins.

Using the escapement design data, the centre line of the lever will be positioned to one side of the line PS which joins the balance staff and the pallet staff. The angle between the centre line of the lever and the line PS will be half the escaping arc (escaping arc = 10^{o}, escaping arc X 0.5 = 5^{o}) plus the allowance for run to the banking (½^{o}) – a total of 5½^{o}. The run to the banking is necessary because of the small errors in concentricity and division which will be present in any escape wheel. It is therefore necessary for the lever to move slightly further on some teeth than others to ensure every tooth can escape.

The position of the centre of the impulse pin can be determined from the escapement design data. The escaping arc is 10^{o}; the allowance for the run to the banking is ½^{o} on each side, thus giving a total angular travel for the lever of 11^{o}.

Since the action is symmetrical about the line of centres joining the balance staff and the pallet staff, half this total angle, or 5½^{o}, will lie on either side of the line PS drawn from the centre of the pallet staff, P, at the instant the impulse pin picks up the notch of the lever.

The engaging arc of the balance is 34^{o}, half this angle, or 17^{o} of the action, will take place on either side of the centre line PS. At the instant when the actions commences, the impulse pin must lie on a line at 17^{o} from the centre line PS, drawn from the centre of the balance staff, S.

3. Draw a line from **P** at an angle of 5½^{o} anti-clockwise of **PS** (to the left of the centre line **PS**) to represent the centre line of the lever at the instant of the commencement of the action – Figure 27.

4. Draw another line from **S** at an angle of 17^{o} to the left of the centre line, and towards the bottom of the paper – Figure 27.

5. Letter the point of intersection of these two lines, one from the pallet staff and the other from the balance staff, '**A**' – Figure 27.

The point A defines the centre of the impulse pin at the instant the action commences.

6. Using the centre of the balance staff, draw an arc through point **A** to define the path of the centre of the impulse pin – Figure 27.

7. Now draw in the impulse pin, using the escapement design data; the flat must lie at right-angles to the line **SA**. The rounded corners have been drawn with radius 0.06 mm – Figure 27.

8. Having found the radius at which the centre of the impulse pin revolves, draw a circle with radius 0.6 of **SA** to define the circumference of the safety roller – Figure 27.

9. Draw another circle with radius twice that of the safety roller to represent the circumference of the large roller – Figure 27.

10. Draw lines on each side of the centre line of the lever, parallel to and 0.3 mm (half the diameter of the impulse pin) away from the centre line of the lever. These lines define the flanks of the notch – Figure 27.

NOTCH AND HORNS

The point of junction between the flank of the notch and the horn of the lever is determined by considering the freedom of entry of the impulse pin into the notch.

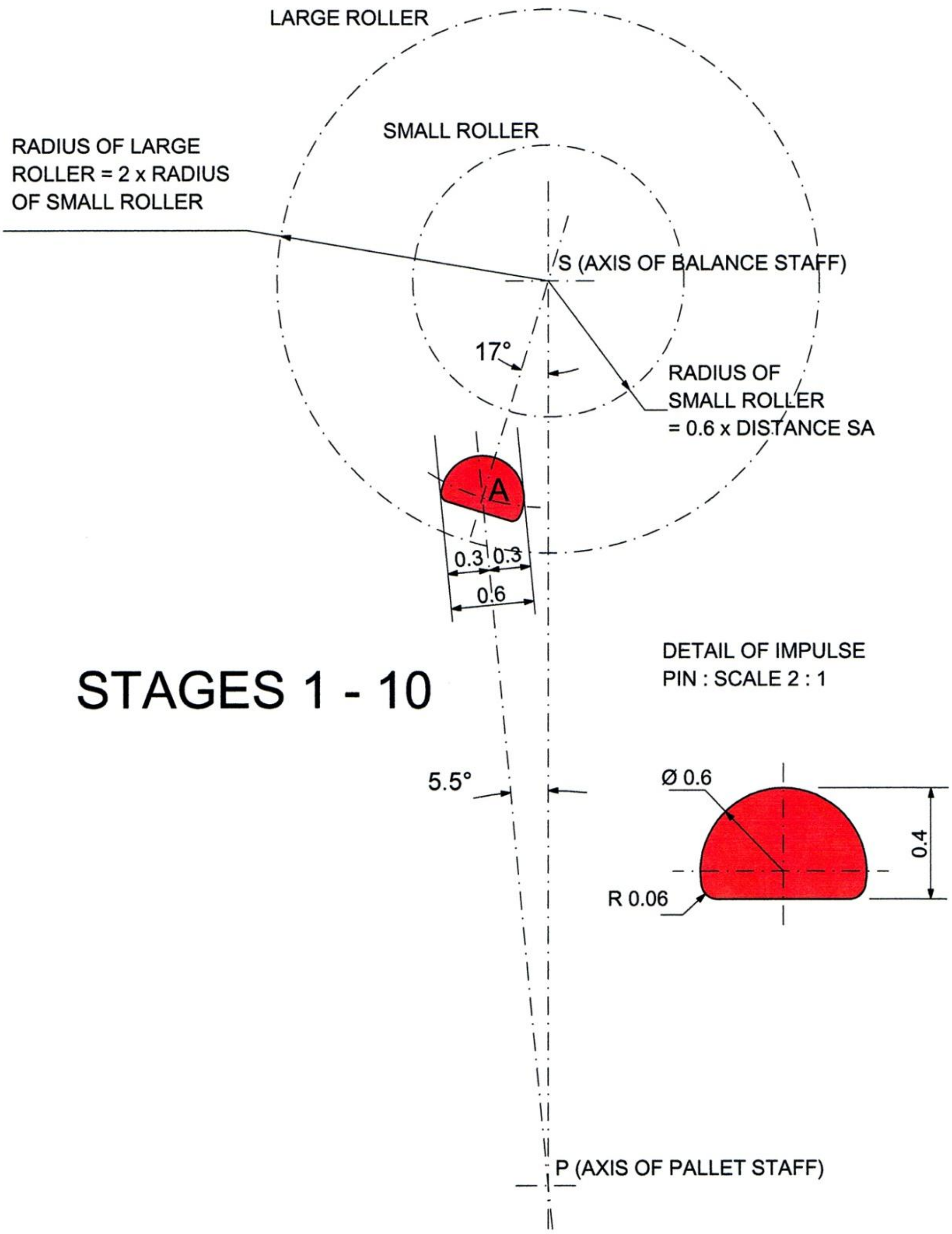

Figure 27 - notch and roller, stages 1- 10

This can be defined by drawing the lever in a position having revolved about the pallet staff through ½° in a clockwise direction. The value of ½° is arbitrary and would be approximately the value used in good quality escapements. In this rotated position, the junction between the notch and the horn is the point at which the flank of the notch would just touch the impulse pin. If the impulse pin is of D-shape, with its thickness equal to two-thirds of its diameter, it will be found that the line defining the flank of the notch will be approximately tangential to the trailing edge of the impulse pin.

11. Draw a line from P at an angle of ½° clockwise of **PA**, nearer to the centre line, to represent the centre line of the lever when advanced ½° – Figure 28.

12. Draw faint lines to represent the flanks of the notch, with the lever in this advanced position (dashed blue lines in the drawing) – Figure 28.

13. The point where the flank of the notch in this position just touches the impulse pin defines the junction of the flank of the notch with the horn – Figure 28.

14. This position can be transferred to the notch in its actual position by drawing an arc using centre **P** through the contact point just defined. The junction between the flank of the notch and the horn of the lever is the point where this arc intersects the flank of the notch. Letter this point '**J**'. As the fork and roller action must be symmetrical on both sides of the centre line of the escapement, both flanks of the notch must be of the same length. The point at which this arc intersects the opposite flank of the notch defines the point of junction of that flank of the notch with its horn – Figure 28.

The path of the impulse pin and the bottom of the notch

The depth of the notch is relatively unimportant, provided that it clears the impulse pin at its deepest point. This condition will occur on the line of centres; the clearance should be between 0.1mm and 0.2mm.

15. Draw an arc from **S** with radius equal to the extremity of the impulse pin (from **S** to either the leading or trailing edge of the flat of the pin). This arc defines the path traced by the extremities of the impulse pin. Letter the point of intersection with the centre line '**H**' – Figure 28.

16. Add 0.1 mm linear clearance on the centre line from **H** and letter this point '**N'** – Figure 28**.**

17. Draw an arc from P with radius the distance **PN** to define the position of the bottom of the notch – Figure 28.

18. Draw a line at right angles to the centre line of the lever through the point of intersection with the arc defining the bottom of the notch – Figure 28.

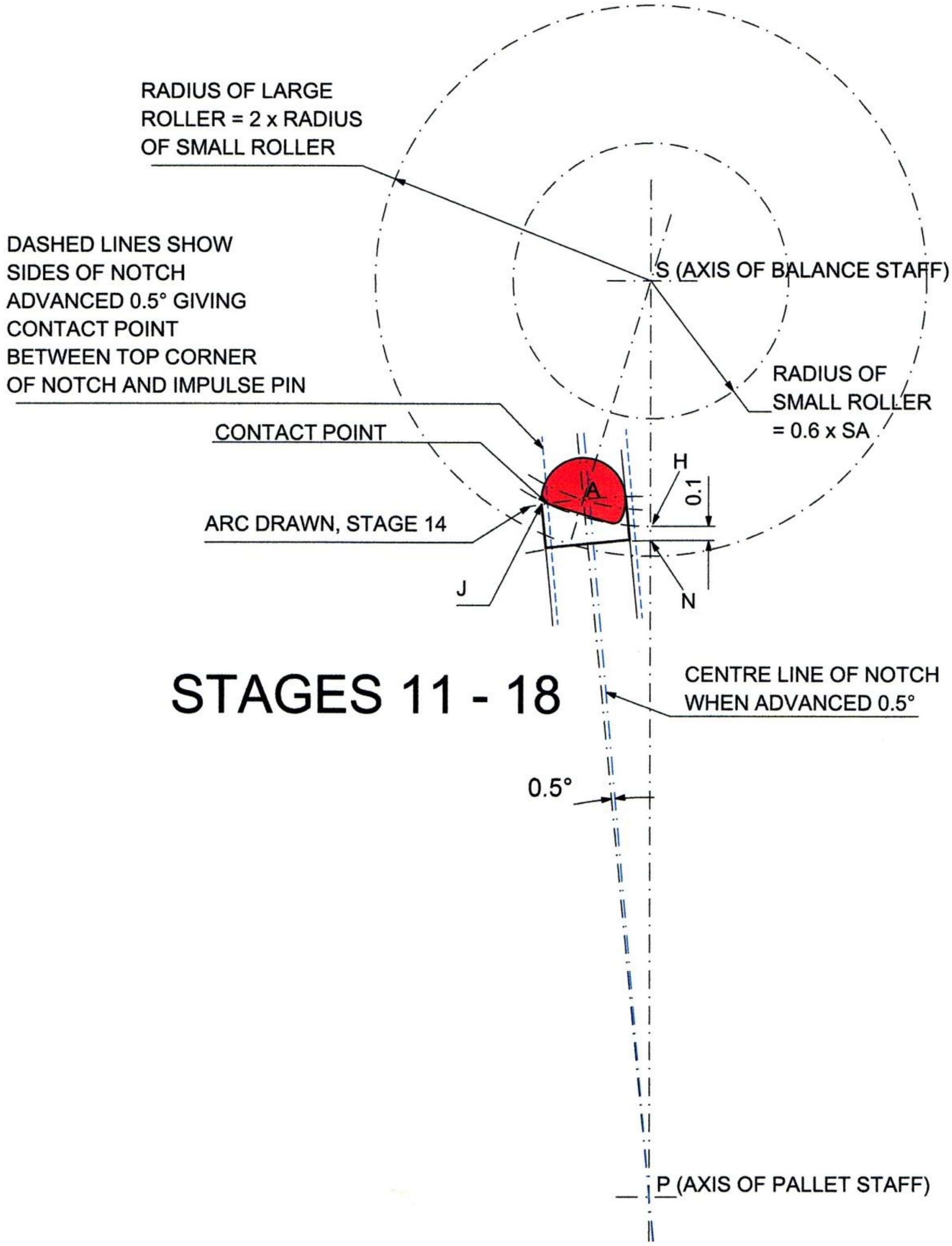

Figure 28 - notch and roller, stages 11 – 18, enlarged detail given in Figure 29

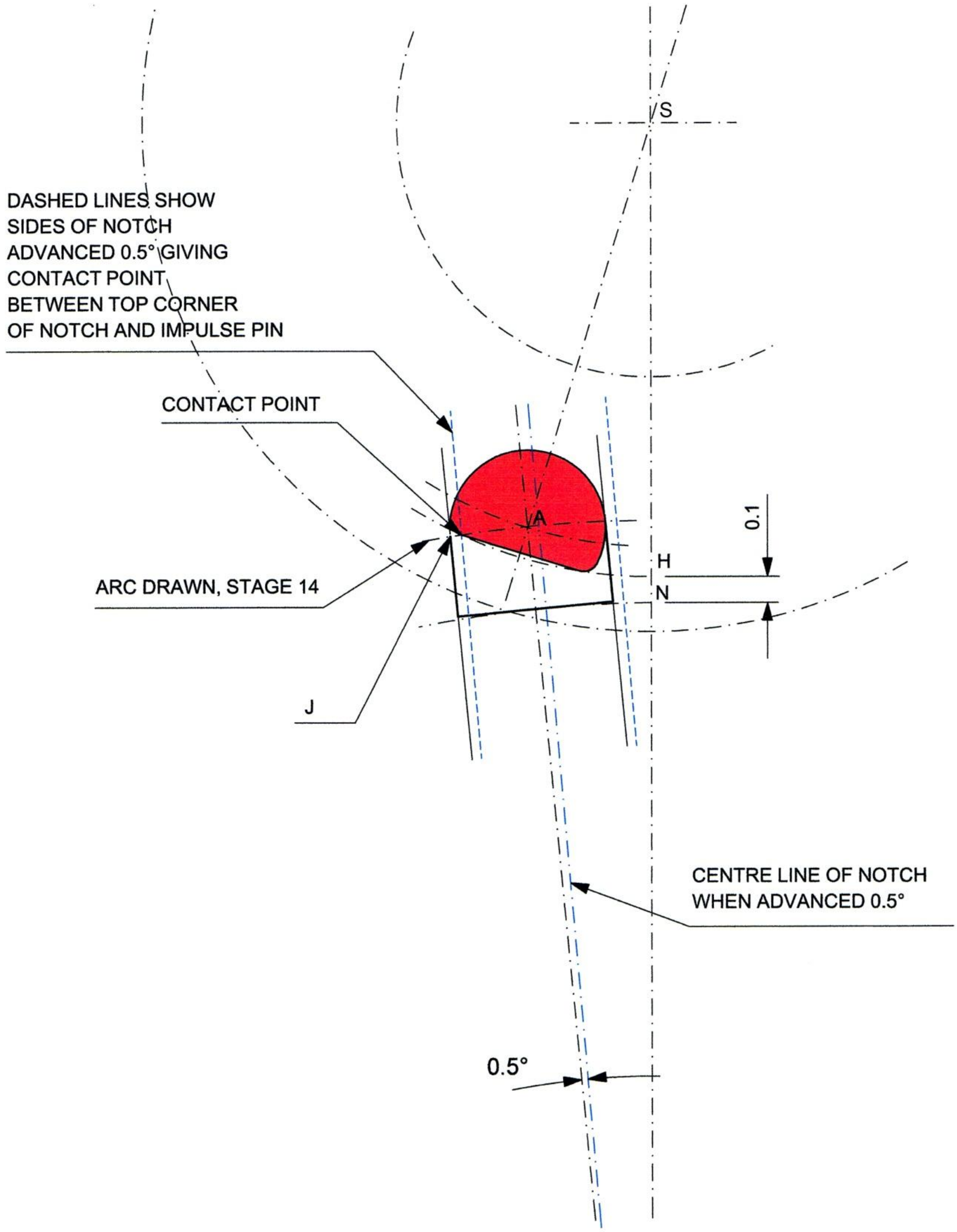

Figure 29 - drawing the notch, enlarged detail

5.2 The safety action – drawing the guard pin

The points that have to be determined in the safety action are:

- tip of the guard pin
- point of commencement of the minimum passing hollow
- depth of the minimum passing hollow

The guard pin will normally be kept out of contact with the safety roller by the action of the draw. The lever will, therefore, normally be lying against one or other of the banking pins during the supplementary arc of the balance. The tip of the guard pin lies on the centre line of the lever at such a distance from the pallet staff that rotation of the lever through the angle of guard pin clearance in a clockwise direction will bring it on to the circumference of the safety roller. In this case the guard pin clearance is 1^{o}.

1. Draw a line from **P** at an angle of 1^{o} clockwise to the line **PA**; extend this line until it cuts the arc denoting the diameter of the small roller. Letter this point **F** – Figure 30.

   This gives the length of the guard pin at the point where it touches the small roller. It is known as the guard pin intersection.

2. Using centre P, the axis of the pallet staff, draw an arc through **F**. The point where this arc cuts the centre line of the pallets is the tip of the guard pin when the lever is against the left banking pin. Letter this point **R** – Figure 30.

3. Draw the guard pin using the dimensions in the detail drawing – Figure 30.

The centre lines have been 'broken' in Figure 30 to enable a larger scale to be used.

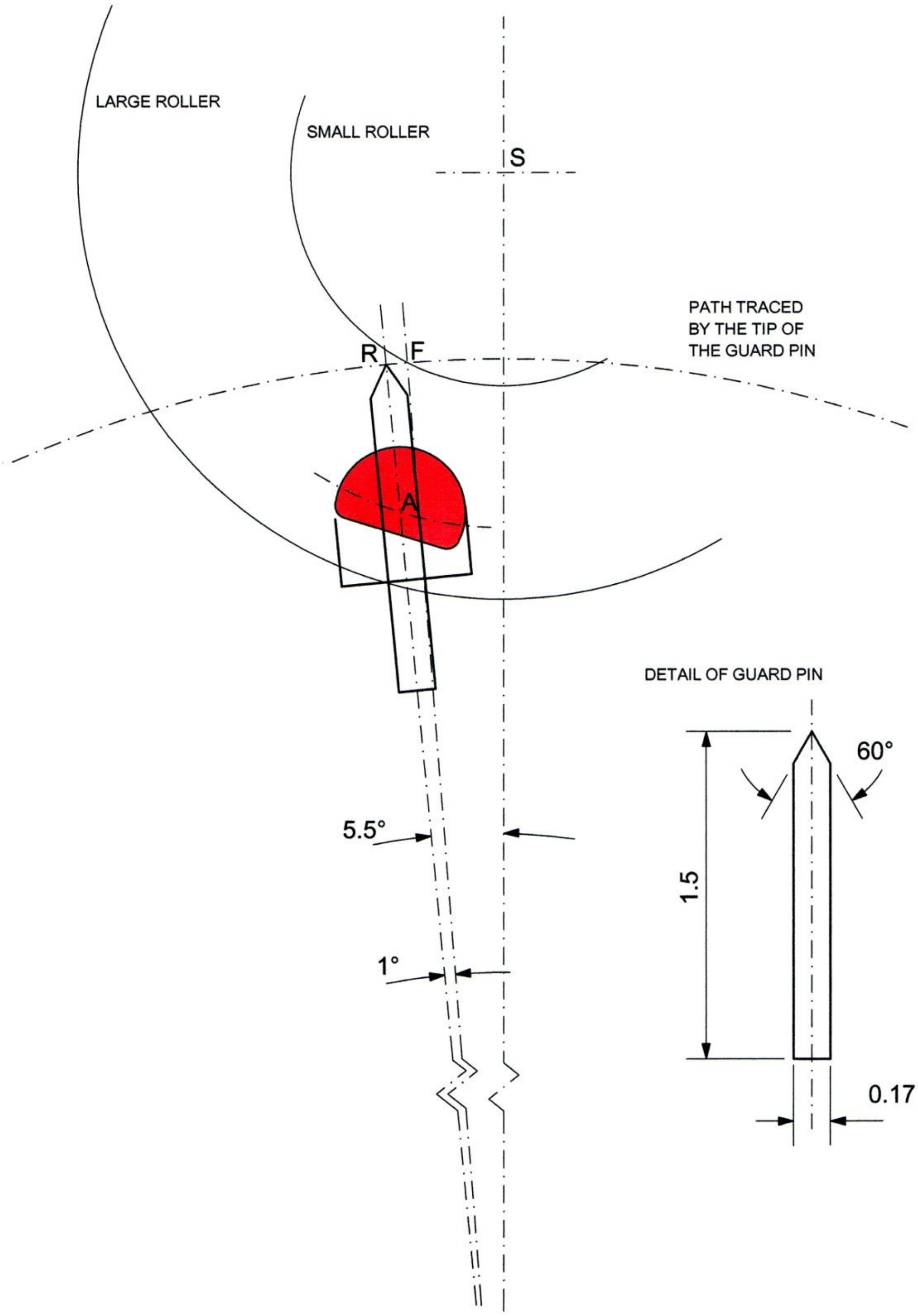

Figure 30 - drawing the guard pin

5.3 The geometry of the passing hollow

Having drawn the guard pin, we must determine the minimum size of a passing hollow (passing crescent) which will allow the guard pin to pass. The hollow will be drawn using a circular form; this will be sufficiently accurate for the drawing.

*Assume that the impulse pin has just entered into contact with the notch of the lever. The safety roller is revolving with the balance staff and the action of the impulse pin causes the lever also to turn about the pallet staff. The guard pin will be brought over towards the centre line of the escapement and it will intersect the circumference of the safety roller at the point **F**, the guard pin intersection – Figure 31.*

During the fork and roller action, the roller will turn through the engaging arc of the balance (34^o) and the lever will turn through the total angular travel from one banking pin to the other banking pin (11^o). For every degree of motion of the lever, the roller will therefore have to revolve through an angle approximately equal to the engaging arc of the balance divided by the total angular travel of the lever. In this case, with an engaging arc of 34^o and the lever moving through 11^o, the roller will have to revolve through $^{34}/_{11}$ x 1 after the impulse pin has picked up the notch, in order to bring the guard pin over to the guard pin intersection (point F)

To determine the point at which the minimum passing hollow must begin we should:

1. Draw a line **SF**, joining the guard pin intersection to the balance staff – Figure 31.
2. Draw a line from **S**, at an angle of $^{34}/_{11}$ degrees in a clockwise direction to **SF**. The point at which this line intersects the safety roller is the point at which the minimum passing hollow must begin. Letter this point **V –**Figure 31. An alternative approach is given in Figure 32.

*As the action of the escapement must be symmetrical, the other side of the passing hollow must lie anti-clockwise of **SA** by a similar amount.*

3. Using the point at which **SA** intersects the safety roller as a centre, draw an arc through **V** to intersect the safety roller on the other side of line **SA**. The point of intersection of this arc with the safety roller defines the opposite end of the minimum passing hollow. Letter this point **Z –** Figure 31.

The depth of the minimum passing hollow can be determined

*The guard pin will have entered most deeply into engagement with the safety roller when the centre of the impulse pin is on the centre line **PS** of the escapement. The tip of the guard pin will be at its deepest at the point where the path of the tip intersects the line of centres **PS** – point **B**.*

4. Draw an arc using centre **P** through the tip of the guard pin to intersect with the line of centres **PS**. Letter this point **B –** Figure 31.

5. Draw an arc using centre **S**, with radius **SB**; the point at which this arc intersects the line **SA** defines the depth of the minimum passing hollow – Figure 31.

6. The minimum passing crescent can be drawn using a simple construction – detail drawing view – Figure 31.

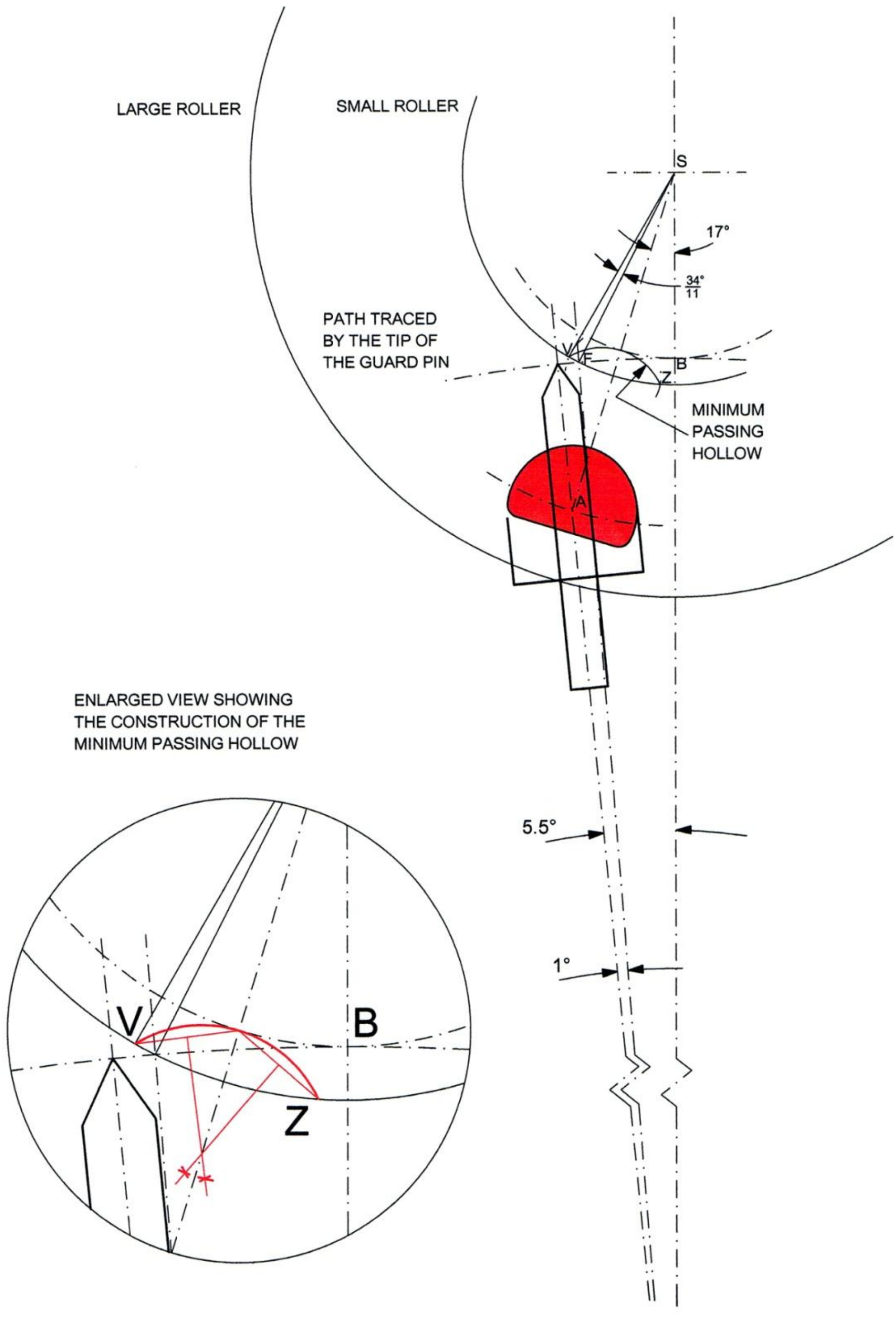

Figure 31 - drawing the minimum passing hollow

An alternative approach for drawing the line SV

The angle $\frac{34^0}{11}$ can be constructed from the drawing and the angle then transferred to the line SF to give the point V.

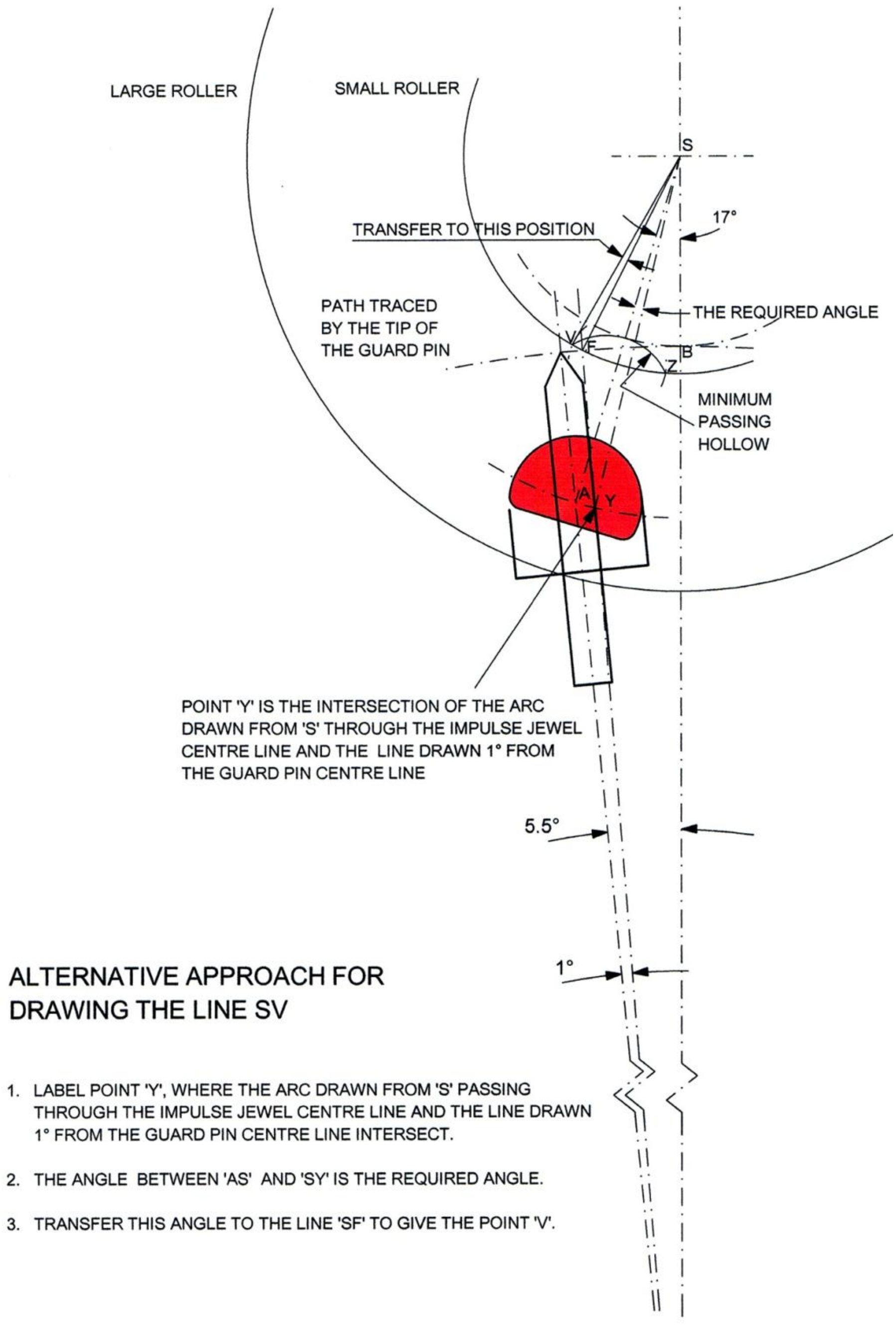

Figure 32 - an alternative approach

In practice, it is necessary to provide clearance between the tip of the guard pin and the passing crescent. This is defined in terms of an angular clearance beyond the minimum passing hollow on either side; a clearance of 5⁰ will be suitable. The passing crescent must be deeper than the minimum; a clearance of 0.1 mm at the centre of the passing hollow will be suitable.

1. Draw a line from **S** at an angle of 5⁰ clockwise of **SV**. The point at which this line intersects the safety roller defines the start of the practical passing hollow – Figure 33.

2. Draw the line **SZ** – Figure 33.

3. Draw a line from **S** at an angle of 5⁰ anticlockwise of **SZ.** The point at which this line intersects the safety roller defines the end of the practical passing hollow – Figure 33.

4. Draw an arc using centre **S** with a radius **SB** minus 0.1 mm linear clearance allowance. The point at which this arc intersects **SA** defines the depth of the practical passing hollow – Figure 33.

5. Use the construction given in the detail drawing in Figure 31 to draw a circular arc through the three points defining the two ends and the depth of the practical passing hollow, to give its true shape. The centre of this arc must lie on the line **SA** – Figure 33.

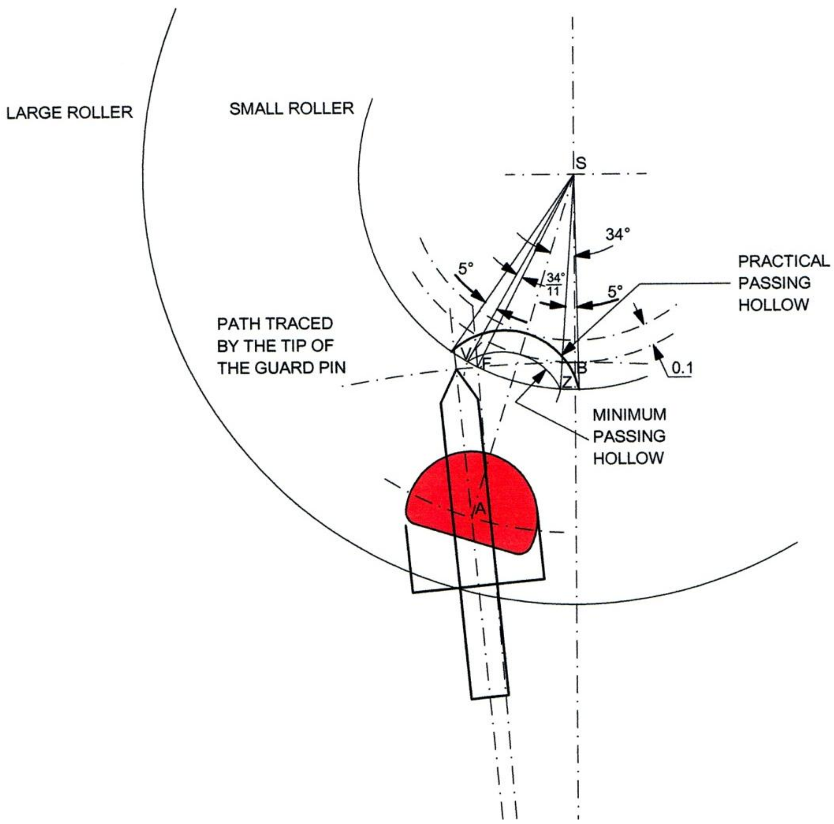

Figure 33 - drawing the practical passing hollow

5.4 The geometry of the horns

Continuing from the drawing of the notch, guard pin and practical passing hollow, we must consider the horns.

It is logical to consider the horns from the instant at which safety, as provided by the guard pin and safety roller, has ceased to be effective, and this happens when the guard pin enters the practical passing hollow at its end nearer to the line of centres of the escapement, at the instant it reaches the guard pin intersection. The position of the impulse pin at this instant should, therefore, be determined.

Let it be supposed that the roller, and with it the impulse pin, has revolved in a clockwise direction until the corner of the practical passing hollow nearer to the line of centres has been brought to the guard pin intersection.

1. Draw in the passing hollow and the impulse pin in this position. (Shown with dashed lines in Figure 34).

The clearance of the tip of the horns must exceed the guard pin clearance and yet still be less than the total lock, otherwise, if the watch had received a shock just before the impulse pin reached the horn, butting might occur if the shock was of such magnitude as to hold the guard pin in contact with the safety roller at this instant. Since total lock, in this case, is 2^{o} and guard pin clearance is 1^{o}, horn clearance of 1½^{o} would be appropriate. This angle is measured from the pallet staff; for convenience it may be taken to the centre of the face of the impulse pin, since the exact length of the horns is not critical, provided they fairly intersect the impulse pin at the instant when safety, as provided by the guard pin and safety roller ceases to be effective.

2. From **P** draw a line to the centre of the face of the impulse pin in its advanced position. Letter this point **U –** Figure 34**.**

3. From **P**, draw a line 1½^{o} anti-clockwise of **PU** to represent horn clearance. (Away from the line of centres **PS**) – Figure 34.

4. Draw an arc using centre **P**, with radius **PU**. The point at which this arc intersects the line just drawn will define the tip of the horn. Letter this point **X –** Figure 34.

ARC OF HORN FACE

The arc representing the horn face must now be drawn. The tip of the horn and its point of junction with the lever notch have already been determined. A satisfactory method is to take the maximum radius of the impulse pin, as measured from the balance staff; there can then be no risk whatever of the horn fouling the impulse pin. An arc with this radius must evidently be drawn from a centre displaced from the balance staff so that it may pass through the tip of the horn and its junction with the notch.

5. Using centre **S**, draw an arc through the extremities of the impulse pin – Figure 34.

6. Find the centre of the arc between the tip of the horn, **X**, and the point where the horn meets the notch, **J**. Using radius equal to the maximum radius of the impulse pin, draw two small arcs, one from the tip of the horn and the other from the point where the horn meets the notch. Letter the point where these arcs intersect **H –** Figure 34.

7. Using Centre **H**, draw an arc intersecting the tip of the horn and its junction with the notch of the lever – Figure 34.

8. Draw the second horn symmetrical to the first horn through the point where the other side of the notch meets the horn – Figure 34.

9. Use the dimensions in Figure 34 to complete the horns.

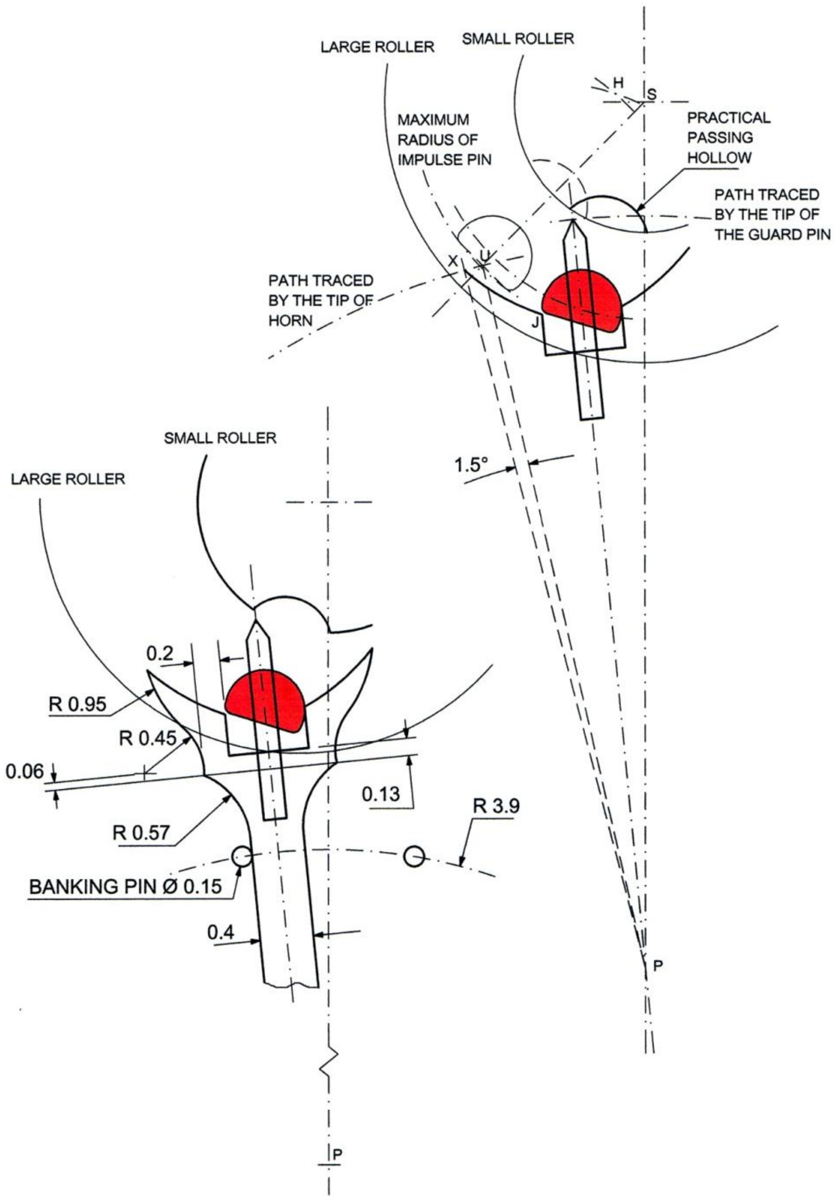

Figure 34 - drawing the horns

Drawing Escapements – Specimen Papers

6 Specimen Papers

1.1 Introduction - the examination

A reminder, the examination for the unit 'D6 : Drawing Clock / Watch Escapements' comprises two parts:

1 There is a three hour invigilated drawing examination; a pictorial drawing showing an escapement or part of an escapement is provided. You are required to draw the required elevations using the appropriate geometrical construction for the escapement or part of an escapement. There is a separate 'clock' and 'watch' examination paper.

   During the examination, you may refer to the details of the geometric constructions given in this booklet.

   The drawing may be produced manually (A2 paper) or using CAD. If CAD is used, hard copy is required (A4 / A3 paper) together with a CD-rom with the file saved hourly and at the end of the examination.

2 You are required to complete a drawing for assessment. The details for this drawing are determined by the Examinations Board and circulated to candidates after the closing date for examination entries. There may be a separate 'clock' and 'watch' drawing.

   This drawing may be produced manually (A2 paper) or using CAD. If CAD is used, hard copy is required (A4 / A3 paper). You are permitted to refer to the geometric constructions given in this booklet.

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D6 : Drawing Clock / Watch Escapements

Specimen 'Clock' Paper

Time allowed : 3 HOURS

Important notes - please read carefully

The drawing shows the components of a 'Recoil Escape Wheel and Pallet Assembly' in an 'exploded' view; the parts are to be assembled in your drawing.

Any dimensions or details not present are to be determined by the candidate.

Instructions:

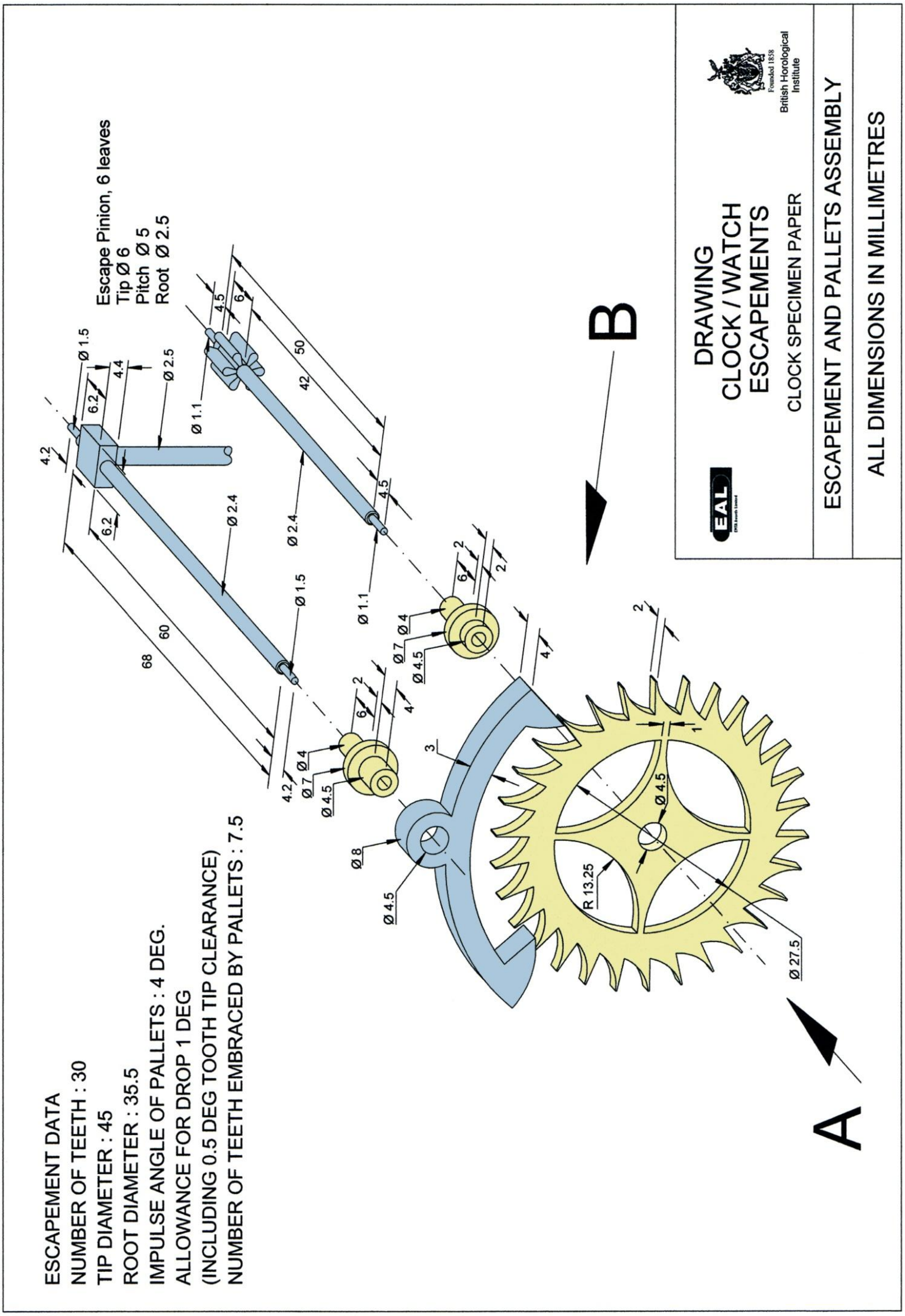
- Draw in orthographic projection to BS 8888 (as detailed in PP8888), to a scale three times full size, two views of the **'**Recoil Escape Wheel and Pallet Assembly' shown in the accompanying pictorial drawing (candidates using CAD and printing on A3 paper are to use a scale of two times full size).

  1. A front elevation as viewed in the direction of the arrow A. The pallets are to be constructed using the geometric construction in the booklet 'Drawing Clock and Watch Escapements'; you may refer to the booklet during the examination. Show construction lines and the specified letters for the points used in the construction
  2. A sectional side elevation in the direction of the arrow B. The cutting plane is to be drawn vertically through the centre line of the pallet arbor and the escape wheel arbor. No hidden detail is required on this elevation.

  The escape wheel and the pallets are riveted to collets which are soft soldered to the arbor. The crutch is riveted to the pallet arbor. Candidates are not required to show these constructional details in the drawing.

  Candidates using a pencil and drawing instruments are only required to draw the upper half of the wheel.

- Add a title block and **ten** dimensions.


ESCAPEMENT DATA
NUMBER OF TEETH : 30
TIP DIAMETER : 45
ROOT DIAMETER : 35.5
IMPULSE ANGLE OF PALLETS : 4 DEG.
ALLOWANCE FOR DROP 1 DEG
(INCLUDING 0.5 DEG TOOTH TIP CLEARANCE)
NUMBER OF TEETH EMBRACED BY PALLETS : 7.5
A
B
Escape Pinion, 6 leaves
Tip Ø 6
Pitch Ø 5
Root Ø 2.5
Ø 27.5
R 13.25
Ø 4.5
Ø 8
Ø 7
Ø 4
Ø 1.5
Ø 1.1
Ø 2.4
Ø 2.5
68
60
50
42
DRAWING
CLOCK / WATCH
ESCAPEMENTS
CLOCK SPECIMEN PAPER
EAL
British Horological Institute
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ESCAPEMENT AND PALLETS ASSEMBLY
ALL DIMENSIONS IN MILLIMETRES

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D6 : Drawing Clock / Watch Escapements

Specimen 'Watch' Paper

Time allowed : 3 HOURS

Important notes - please read carefully

The drawing shows the components of a 'Roller and Balance Staff Assembly' in an 'exploded' view; the parts are to be assembled in your drawing.

Any dimensions or details not present are to be determined by the candidate.

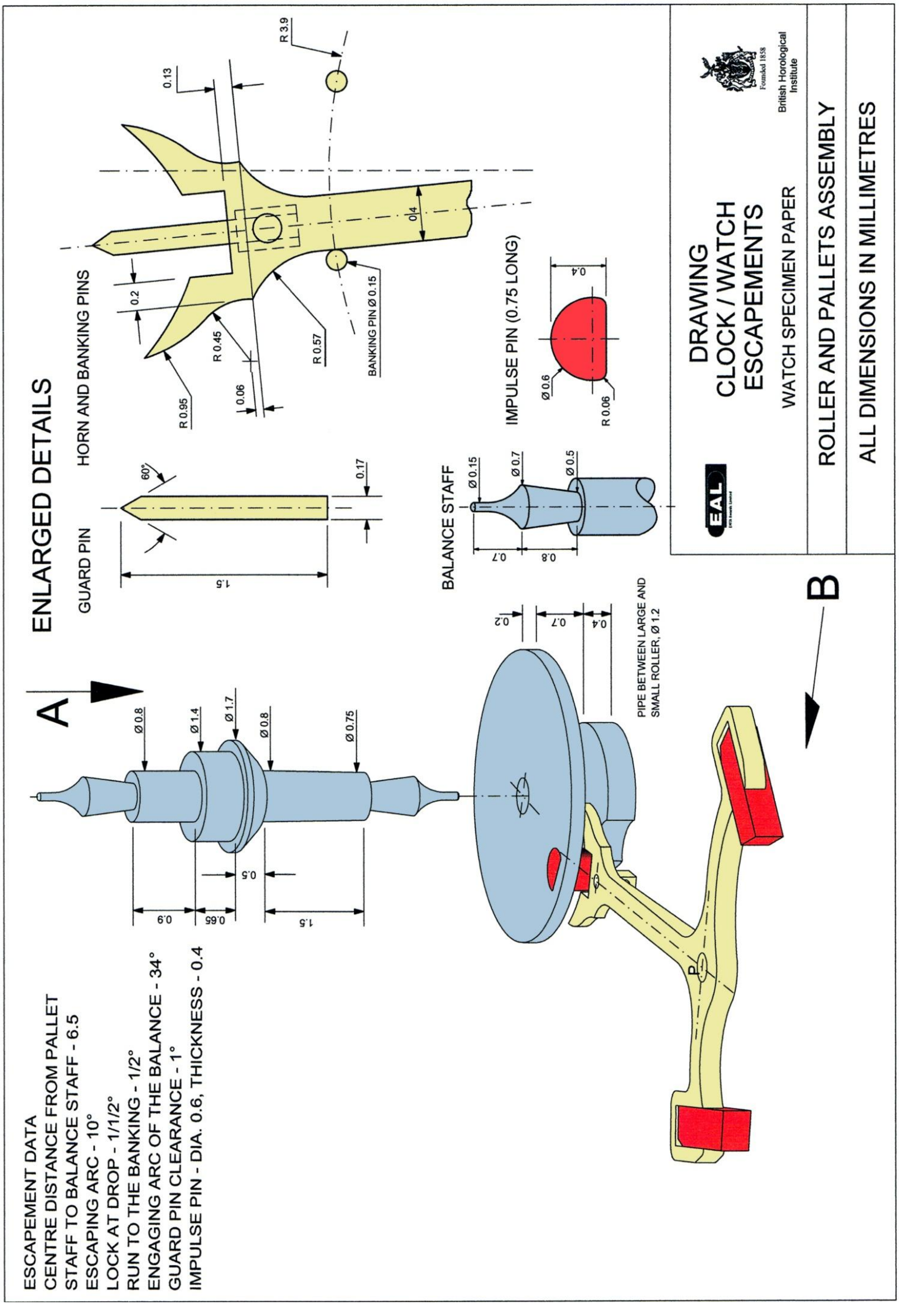
Instructions:

- Draw in orthographic projection to BS 8888 (as detailed in PP8888), to a scale forty times full size, (candidates using CAD and printing on A3 paper are to use a scale of twenty five times full size) two views of the **'**Roller and Balance Staff Assembly' shown in the accompanying pictorial drawing. The roller is a friction fit on the balance staff.

    1. A front elevation as viewed in the direction of the arrow A. The roller is to be constructed using the geometric construction in the booklet 'Drawing Clock and Watch Escapements'; you may refer to the booklet during the examination. Show construction lines and the specified letters for the points used for the construction. Only the 'notch end' of the pallets should be drawn.

    2. A sectional side elevation in the direction of the arrow B. The cutting plane is to be drawn vertically through the centre line of the balance staff. The pallets and hidden detail are not required on this elevation.

- Add a title block and **ten** dimensions.


ESCAPEMENT DATA
CENTRE DISTANCE FROM PALLET STAFF TO BALANCE STAFF - 6.5
ESCAPING ARC - 10°
LOCK AT DROP - 1/1/2°
RUN TO THE BANKING - 1/2°
ENGAGING ARC OF THE BALANCE - 34°
GUARD PIN CLEARANCE - 1°
IMPULSE PIN - DIA. 0.6, THICKNESS - 0.4
A
B
Ø 0.8
Ø 1.4
Ø 1.7
Ø 0.8
Ø 0.75
0.9
0.65
0.5
1.5
0.2
0.7
0.4
PIPE BETWEEN LARGE AND SMALL ROLLER, Ø 1.2
ENLARGED DETAILS
GUARD PIN
60°
0.17
1.5
HORN AND BANKING PINS
0.2
R 0.95
R 0.45
0.06
R 0.57
BANKING PIN Ø 0.15
0.13
R 3.9
Ø 4
BALANCE STAFF
Ø 0.15
Ø 0.7
Ø 0.5
0.7
0.8
IMPULSE PIN (0.75 LONG)
Ø 0.6
R 0.06
0.4
DRAWING CLOCK / WATCH ESCAPEMENTS
WATCH SPECIMEN PAPER
ROLLER AND PALLETS ASSEMBLY
ALL DIMENSIONS IN MILLIMETRES
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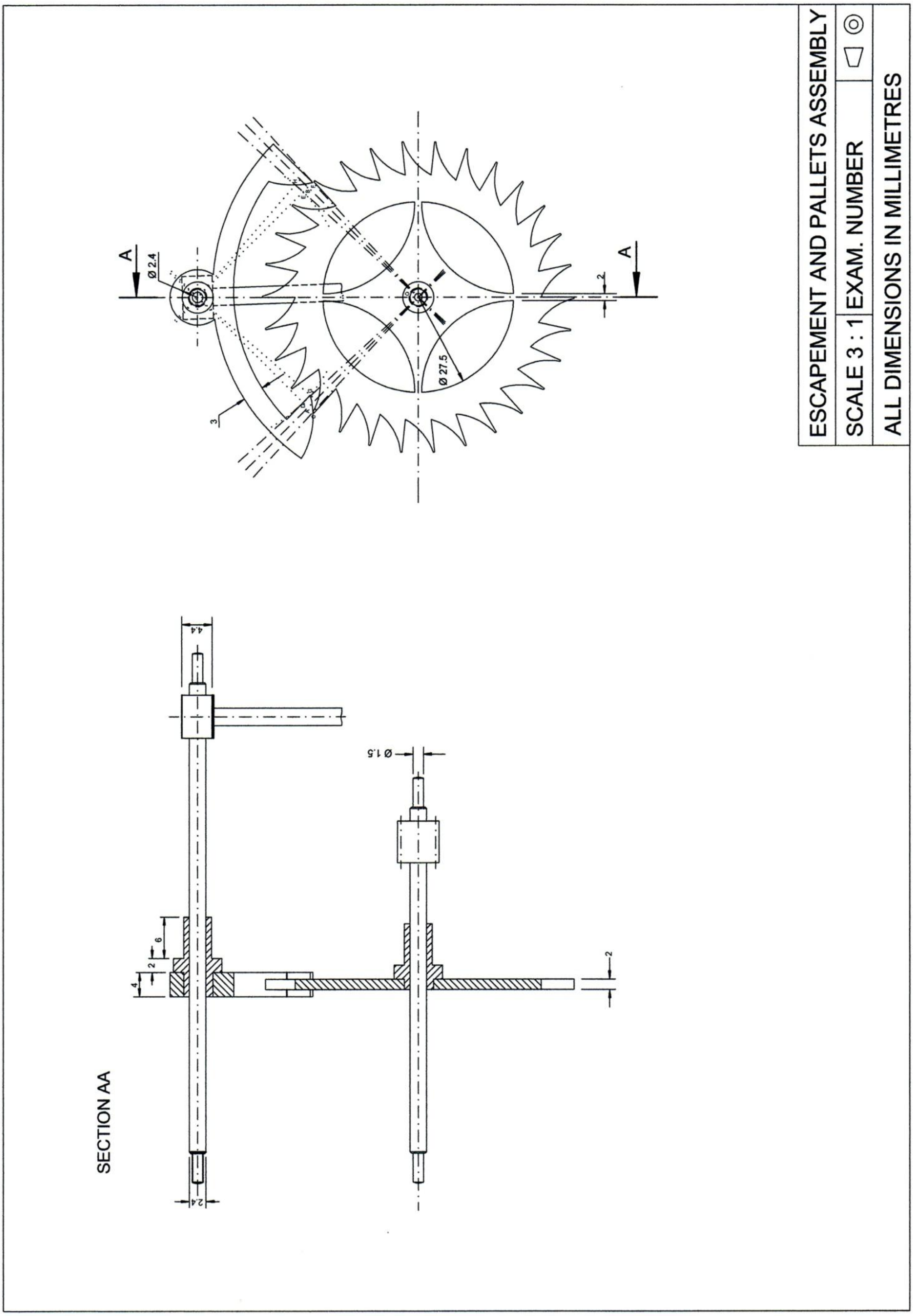
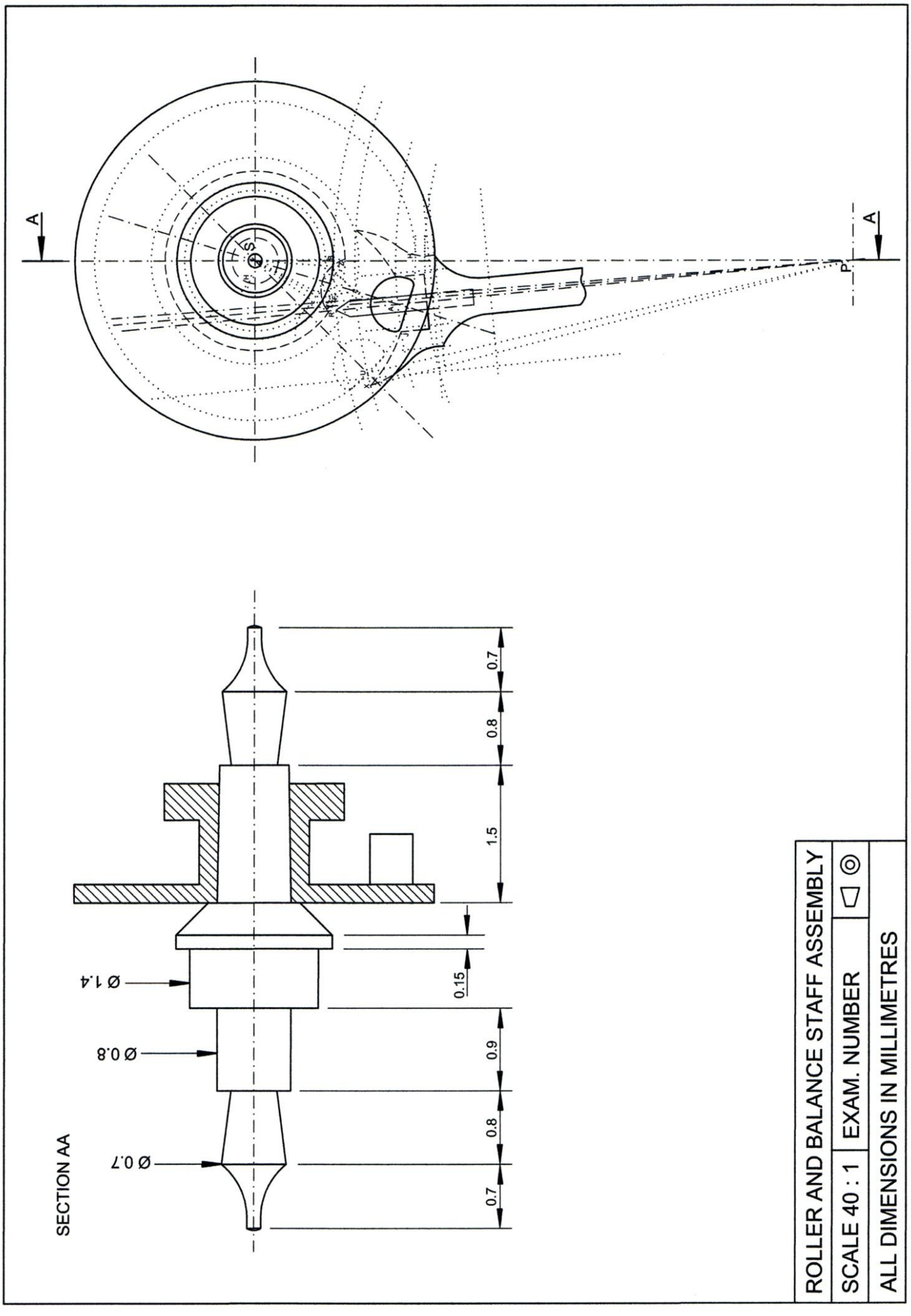
Specimen Papers – Model Answers

7 Model answers

A model answer is provided on the following pages for both the ‘clock’ and the ‘watch’ specimen papers. They are intended to provide overall guidance for the candidate; the size of the model answer drawing prevents every detail being clearly visible.

The scale given in the title block relates to the size originally drawn; the drawings have been reduced for the purposes of the booklet.


ESCAPEMENT AND PALLETS ASSEMBLY
SCALE 3 : 1
EXAM. NUMBER
ALL DIMENSIONS IN MILLIMETRES
SECTION AA
A
A
Ø 2.4
Ø 27.5
Ø 1.5
4.4
2.4
3
2
4
2
6
2


A
A
P
S
SECTION AA
Ø 1.4
Ø 0.8
Ø 0.7
0.7
0.8
1.5
0.15
0.9
0.8
0.7
ROLLER AND BALANCE STAFF ASSEMBLY
SCALE 40 : 1
EXAM. NUMBER
ALL DIMENSIONS IN MILLIMETRES